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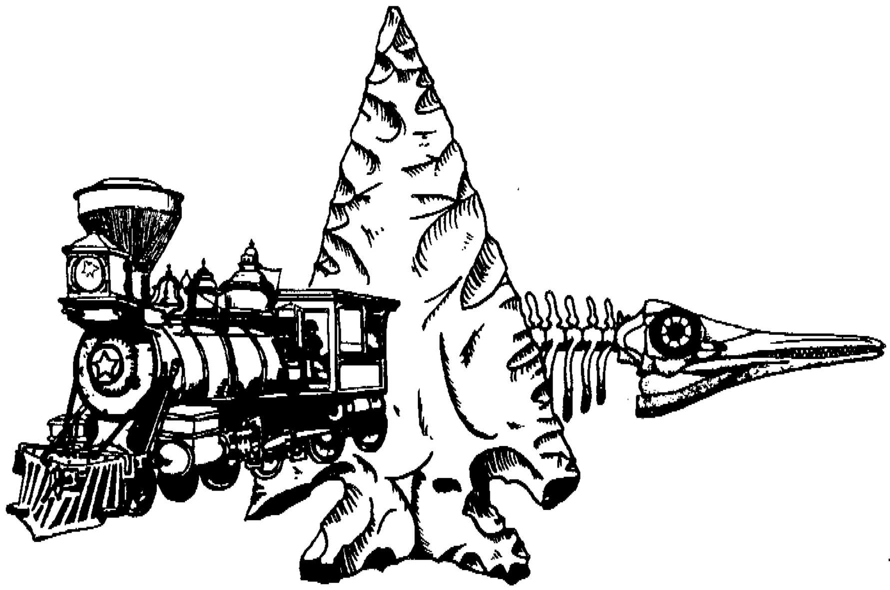

THE BOVINE BLUFF SITE:

An Early Puebloan Site in the Upper Moapa Valley

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Margaret M. Lyneis

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THE BOVINE BLUFF SITE:
AN EARLY PUEBLOAN SITE IN THE UPPER MOAPA VALLEY

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FOREWARD

In 1983, Keith Myhrer and Margaret M. Lyneis began archaeological investigations at the Bovine Bluff Site (NV-05-2068; 26 CK 3130) near the town of Moapa in Clark County, Nevada. Sponsored primarily by the Department of Anthropology at the University of Nevada, Las Vegas, with assistance from the Bureau of Land Management, these investigations have been aimed at the recovery of data in the face of the impending construction of a Mission by the Catholic Church. Thus far this project has been carried out within the framework of an archaeological field school with the current report developed under the close purview of Thomas Zale.

Bovine Bluff is a multi-component site representing primarily Puebloan occupation with a possible earlier use by Archaic peoples and later use by Paiute Indians. The site has been heavily impacted by pothunting in recent years; nevertheless, the site can still yield significant data as demonstrated in the following pages.

The present document is a progress report describing the results of field investigations completed in 1983 and 1984. Analyses of the surface assemblage collected from the site and materials recovered through limited excavations are presented. Future investigations necessary to complete data recovery efforts at the site are aimed primarily at further sub-surface explorations of the architectural adobe features.

The project reported herein is another example in this publication series of current state-of-the-art archaeological techniques applied to cultural remains which do not appear at first glance, particularly to the layman, to hold much promise for furthering our knowledge of prehistoric lifeways in the Desert West. Though more extensive excavations are planned at the site, already the initial work has demonstrated the contributions which exploration of the site may offer. As such, it is both a much needed contribution to our understanding of the complex prehistory of this area and a tool that will improve our ability to prepare and implement more effective management and mitigation plans for this and similar sites.

Richard C. Hanes
Nevada BLM State Archaeologist
Reno

October, 1985

ACKNOWLEDGMENTS

Support for the archaeology of Bovine Bluff was provided in several ways by the Bureau of Land Management. The major portions of the artifact analyses and the writing of the report, obsidian sourcing and hydration, and preparation of the ceramic thin sections were all funded by the Bureau of Land Management. Dr. Richard Hanes, State Archaeologist, insured the project was proceeding smoothly by periodic checks and offers of assistance. Mr. Stanton Rolf, District Archaeologist, in large part arranged for the funding of the obsidian sourcing and hydration and the ceramic thin sections. Mr. William Civish, Area Manager for the Stateline Resource Area, made available the resources of the local office. The Department of Anthropology, UNLV, provided laboratory and word processing facilities and the Department of Geoscience made available a petrographic microscope for thin section analysis.

Many people have been a part of the data recovery of Bovine Bluff. Renee Hughes assisted Myhrer and a group of volunteers from the Archaeo-Nevada Society provided the labor core for the 25 percent surface collection on three Sundays: January 22, February 12, and March 11, 1984. Those Archaeo-Nevada Society members are:

Sarah Black	Irv Goldstein	Phyllis Sherwood	Glenn Woodall
Grace Burkholder	Helen Mortenson	Richard Stockton	Robert Worts
Pam Busch	Mary Lou Moore	Darlene Thorne	Sue Worts
Helen Dwyer	Mary Rusco	Marion Van Buren	
Annette Goldstein	Elmer Rusco	Virginia Windham	

Other volunteers were Sue Edwards and Lysenda Kirkberg. Vicki Kennard came out one of the Sundays to collect the knapping station.

Sara Black, an Archaeo-Nevada Society volunteer, served as crew member for the field class during the 1983 and 1984 seasons. Student excavators in the 1983 field class were Steve Baird, Sue Edwards, Dawna Ferris, Hal Fischer, Renee Hughes, Vicki Kennard, and Pat Taylor. Excavators in the 1984 field class were Sid Drobkin, Sue Edwards, Renee Hughes, Jackie Lee, Tom Mullins, Carol Patterson, and Blair Wright.

The bulk of the processing of artifacts was completed by a few volunteers from Archaeo-Nevada Society who faithfully arrived one day a week throughout the fall, winter, and spring of 1983 and 1984. More than 500 hours were contributed in cataloguing the artifacts and approximately another 100 hours in weighing the flakes and sherds from the collection. In order of the greatest amount of laboratory time contributed, those people are Helen Dwyer, Robert Worts, Sue Worts, Phyllis Sherwood, John Kepper, Annette Goldstein, and Richard Stockton.

Our understanding of the surficial features of the site has been greatly aided by low-level aerial photography. Hal Fischer, a student in the 1983 field class, flew the site in his private plane on October 8, 1984 while Lyneis took color and black-and-white photos. Our 1983 excavations were backfilled in large part with fill provided by Mr. Sandy Sandoval of Overton. In a search for glaring errors, Felecia Briscoe read through the final draft of the report.

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INTRODUCTION

Bovine Bluff (26 CK 3130) is an early Pueblo II site located on a bluff overlooking the Muddy River. Although its major occupation was by the Virgin Anasazi during the midpoint of the Lost City phase (A.D. 700-1100), separate areas of the site indicate possible Archaic and Paiute occupations.

The Bovine Bluff site was recorded in 1982 by Kevin Rafferty, then Archaeologist for the Stateline Resource Area of the Las Vegas District, Bureau of Land Management (BLM). The inventory (Rafferty 1982) was of an area for which St. John's Catholic Church in Overton, Nevada, had filed an Application for Land for Recreation or Public Purposes (Serial Number N 36669). Concentrations of artifacts and structural remains had previously been recorded in this area by Chick Perkins who identified three sites (26 CK 1841, 26 CK 1842, and 26 CK 1843). Due to difficulties in determining the boundaries of the sites recorded by Perkins, a new designation, 26 CK 3130, was assigned to the material recorded by Rafferty. The BLM site number assigned to this material is NV-05-2068.

In July, 1983, a preliminary mitigation plan for the cultural resources at Bovine Bluff was developed by the BLM, the Department of Anthropology, University of Nevada, Las Vegas (UNLV), and St. John's Catholic Church. Work at the site began on October 8, 1983, with the establishment of grid control points. With Lyneis as Instructor and Myhrer as Teaching Assistant, the UNLV Field Class in Archaeological Methods conducted a total of fifteen days of excavation during the 1983 and 1984 fall semesters. In addition, a 25 percent systematic surface collection was completed by Myhrer, in consultation with Lyneis, during the spring of 1984. The cataloging of artifacts was accomplished primarily by a few volunteers from the Archaeo-Nevada Society under the supervision of Myhrer. Students from the field class also processed some of the artifacts as part of their assigned work. Analysis of the artifacts was accomplished by Myhrer while employed by the BLM.

The purpose of this report is to describe, analyze, and provide suggestions for the interpretation of archaeological data recovered from the Bovine Bluff site.

LOCATION AND ENVIRONMENT

Bovine Bluff is located in the upper Moapa Valley approximately 80 kilometers north-northeast of Las Vegas, Nevada (USGS Moapa Quadrangle, 15 minute series, 1958). Figure 1 is a regional map of the Moapa Valley. Figure 2 is a map of the site. The elevation of the site is aproximately 490 meters above mean sea level. The present channel of the Muddy River is located approximately 100 meters south of the site.

Geology

The Moapa Valley is a result of erosional processes produced by the cutting action of a regional draining of southeastern Nevada. Gardner (1968) recognizes three pluvial episodes of surface formation that occurred between the deposition of the Muddy Creek Formation and the action of recent erosional processes. These formations are the Mormon Surface, the Overton Surface, and the Lost City Surface on which the remains of Puebloan occupation stand including Bovine Bluff. Most of the variation in the Lost City Surface elevation is due to the downcutting and meandering of the Muddy River channel.

The Muddy River, its source at several warm springs just below Arrow Canyon, flows approximately 48 kilometers southeast from Moapa, Nevada, through the Moapa Valley, eventually joining the Virgin River in what is now Lake Mead. The total potential watershed of the Muddy River is 11,270 square kilometers. Longwell (1928) and Gardner (1968) report that prior to 1880 the Muddy River wandered over the floodplain surface in a braided manner. At that time, severe floods cut the channels of the Muddy River 6 to 9 meters into the recently deposited valley fill.

Climate

The present climate of the Moapa Valley is characterized by long, hot summers and warm winters. The average summer temperature is 85 degrees F. and the winter temperature averages 46 degrees F. The average percentage of humidity ranges from 20 to 30 percent. The average length of the growing season is 224 days. Rainfall, with a winter-dominant intensity, is usually less than 5 inches per year. Summer precipitation usually occurs in cloudbursts (Bagley 1980:5).

Reconstruction of paleoecological conditions for the last 18,000 years is primarily based on vegetation data from packrat (Neotoma spp) middens. Madsen's (1972) research in the nearby area of Meadow Valley Wash indicated that a transition occurred from an oak and pine woodland to a juniper-sagebrush-pine woodland like that of today. A slight warming trend, following a minor cooling trend from 7000-2000 B.P., could be implied for this time period. Weide's (1982) paleoecological synthesis for the southern Great Basin was based on local and regional models developed through research with packrat middens and pollen analysis. Weide concluded that on a broad scale cyclical droughts were interspersed within larger periods of normal precipitation in the last 2,200 years. Beyond this, a more complete localized climatic description is not available.

Flora and Fauna

Bradley and Deacon (1965) provide an extensive study of the biotic communities of southern Nevada. Three biotic communities are represented in the immediate area around Bovine Bluff.

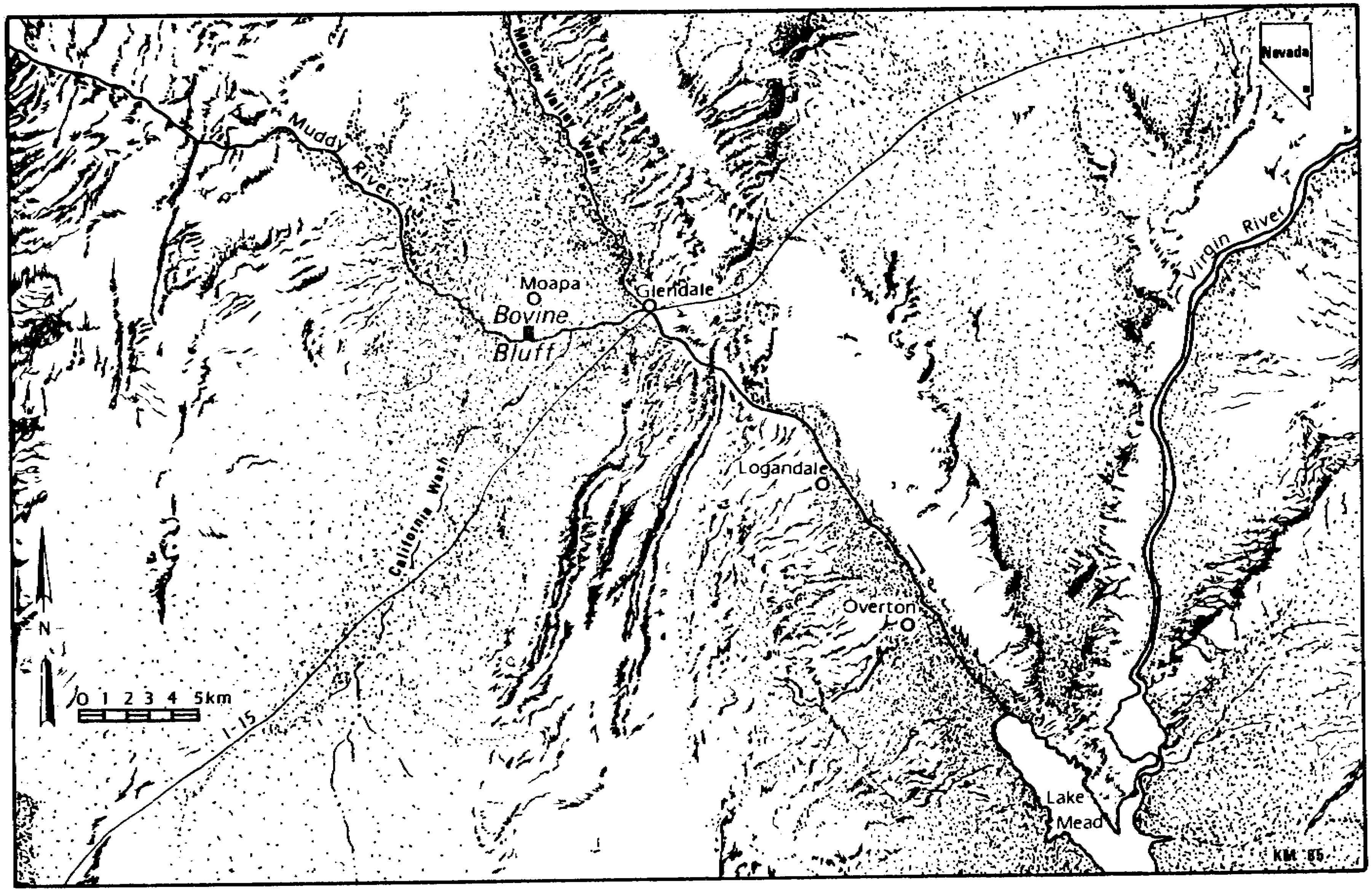

Figure 1. Map of Moapa Valley, Nevada.

Creosote Bush Community. Creosote bush (*Larrea divaricata*) and Burro bush (*Franseria dumosa*) dominate. The Mojave Yucca and cacti including prickley pears and chollas, barrel cactus and others are well represented. Reptiles and lizards are common. Several mammal species are abundant including several species of carnivores, bats, and rodents as well as jackrabbits and desert cottontails.

Stream Riparian Community. This community is found along the major streams, including the Muddy River. Willows, mesquite and cottonwoods are numerous. Amphibians and reptiles are common.

Stream Community. This community features dense vegetation in the headwaters of the Muddy River. Downstream the dense vegetation disappears and submergent aquatics are basically absent. Overhanging trees, grass, and shrubs provide cover over the water channel. Some species of native fish are present in the Muddy River.

Soils

The site is situated at the edge of the bluff on the Lost City Surface and overlooks the floodplain of the upper Muddy River. The bluff is formed by about five meters of exposed, interstratified sands and sandstones that are capped by about two meters of water-laid gravels ranging up to cobbles in size. The upper portion of the gravels are firmly cemented with white caliche. Materials for stone tools are close at hand. The site lies on gray, volcanic clast gravel which includes an abundance of volcanic rock types in the gravel size fraction (Gardner 1968:51-52). Gray limestone is also abundant. Varicolored quartzite and chert gravels and red sandstone make up less than five percent of the gravel fraction. Two kinds of stone used for tools do not occur in the immediate vicinity of the site. Obsidian flakes are found on the site in small numbers and the few milling stones present are of a well-cemented sandstone distinct from the crumbly product locally available.

The soil on the surface of the bluff, mapped on a general scale that does not include local variability, is described as Bard gravelly fine sandy loam (Bagley 1980:62). Where undisturbed, a soil has developed ranging in depth from 10 centimeters near the bluff's edge to about 25 centimeters in the area 40 to 50 meters north of the edge of the bluff. The soil is capped by a well-developed gravel armor of pebbles, generally less than five centimeters diameter in size, that rests on a vesicular A horizon a few centimeters thick.

The white sand, silt, and clay in the floodplain are recent surface deposits of the Muddy River. This soil is described as Overton silty clay, slightly saline (Bagley 1980:74). It is well-suited for irrigated crops, limitations being a high water table and a high salt content. Today the floodplain is pasture and feeding station for cattle belonging to the Anderson Dairy. During prehistoric times, the floodplain, with its high water table and the braided nature of the Muddy River, probably supported food crops of the aboriginal occupants.

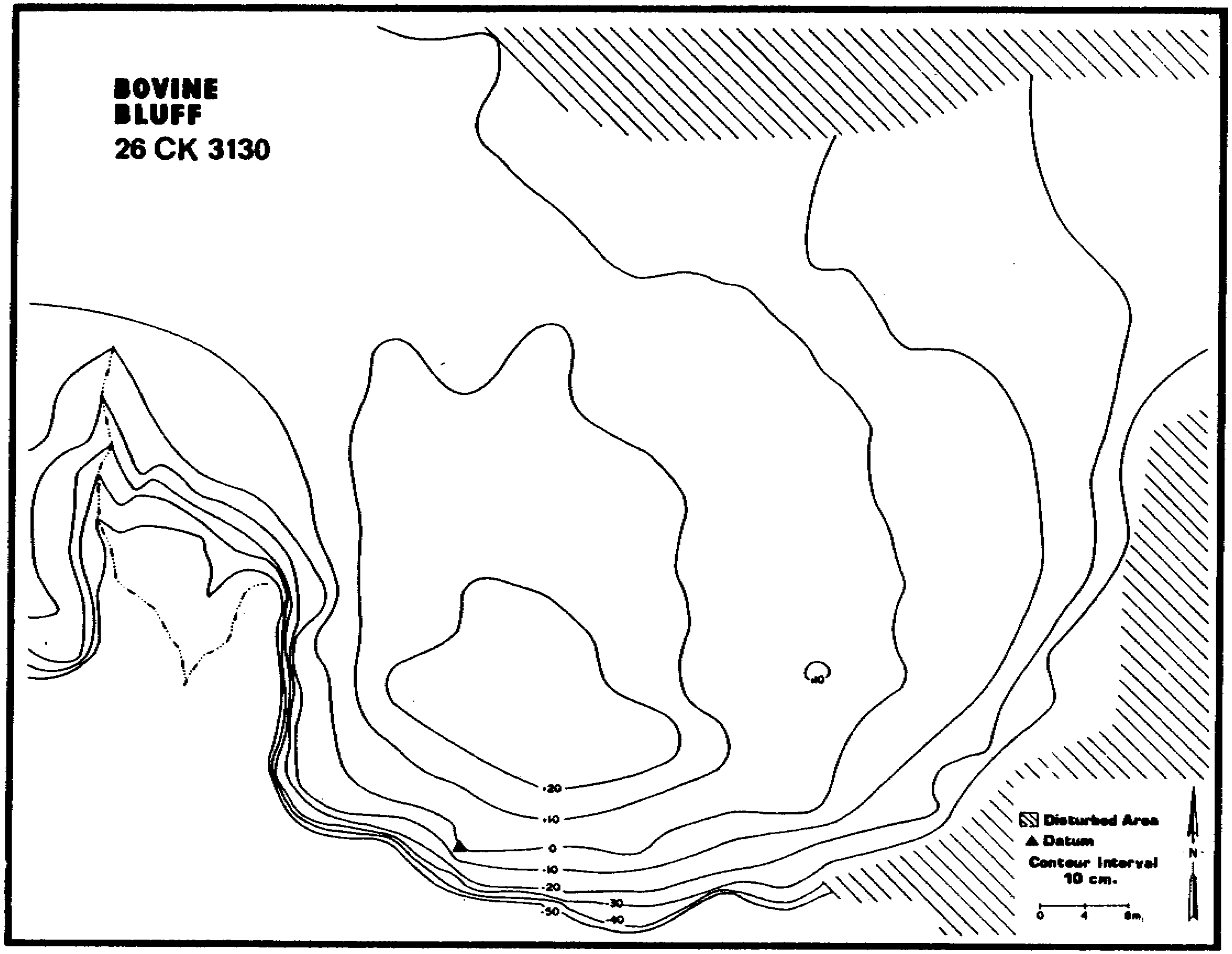

Figure 2. Map of Bovine Bluff.

The nature of the surface soils is such that deposits of silty clay or clay do not occur naturally on the site and must be regarded as cultural remains. It is evident that there was much mud or adobe construction at the site and that the floodplain below served as the source of these construction materials. Other construction materials were even closer at hand. On the face of the bluff below the site, the exposed gravels offer cobbles in an assortment of sizes and shapes. Further downslope, the poorly cemented sandstone units that occur in the bedded sands were apparently the source of slabs used on the site.

FIELD METHODS

The cultural deposits of Bovine Bluff are shallow and have weathered since abandonment lending an obscurity to the architecture that is compounded by extensive disturbance in the core of the site. Experience in the lower valley indicated that architectural plans could often be recovered despite despoilation of structures as a result of a pattern of looting the center of the rooms in search of burials.

Due to the nature of the deposits, almost all of the excavation was done by hand with trowels and brushes. All fill was screened through 1/8 inch mesh to maximize recovery of small beads and bone. All flakes, sherds, artifacts, and charcoal frgaments recovered in the screen were saved. To facilitate flexibility in the size of area to be investigated, excavation units were based on 1 X 1 meter units or multiples thereof. While unit sizes of 1 X 1 and 1 X 2 meters proved ideal as test units, much larger areas were opened for the exploration of floors, surfaces, and potential architecture. Each excavation unit is designated by the grid location of its southeast corner.

Fall 1983 Investigations

Beginning October 15, 1983, eight Saturdays were devoted to field investigations. The initial goal was to investigate a series of features thought to be looted structural remains in the central, most disturbed area of the site. Figure 3 illustrates the locations of the excavated units discussed below.

A grid system expandable to encompass the entire site was first established. Based at a point along the south margin of the site that is 200 meters north and 400 meters west of a hypothetical origin, an accurate X/Y axis, on the 214N and 400W lines, was laid out with the use of an allidade. Much of this original grid was marked with wooden stakes. Since many of the stakes were kicked out by visitors in the absence of the field class, most grid points were subsequently marked by heavy steel nails driven flush with the surface. These nails are virtually invisable in the gravel armor of the site surface and have proven to survive well between work sessions.

Following the establishment of the grid system, a 100 percent surface collection of the central, disturbed portion of the site and an adjacent area to be used for screening was completed. Collection units measured 2 X 2 meters. All sherds and flakes were collected by grid unit. The exact location of all tools and grinding implements within collection units were measured and these artifacts were bagged separately.

We next investigated five depressions, two slab features thought to be potential structures, and an additional area thought to be part of a room alignment. Pits 1 and 3 were sectioned revealing nothing more than potholes. There was no apparent reason why the potholes had been initially dug. Pit 2 proved to be a small, possibly aboriginal, pit with no evidence of lining that was filled with sterile material. Pit 4 included some deposits that appeared to be intact and what may have been a floor of white material with caliche nodules. Investigation of this feature was not completed by the end of the semester and has not yet been completed.

Pit 5 (Figure 3) was designated during the course of work. A test trench intersected a rimmed firepit and further excavation revealed a section of an arc of much-weathered adobe floor. At this time, the exposure was limited to the west half of the structure.

Two areas were investigated where alignments of slabs on edge appeared to outline small structures. In one unit (Figure 3-A), what appeared to be a solid, but mud-cracked layer of adobe was uncovered between the slabs. In a second, adjoining unit (Figure 3-B), excavations to the subsoil of caliche-cemented gravels uncovered no evidence of a floor. If this was a structure, for instance a slab-lined cyst, either it was originally unlined or looting had entirely destroyed whatever flooring it had. It is probable that the slab alignments were originally storage structures.

Unit 203N/396W (Figure 3-C) situated in a cleared area, was considered to be a portion of what was thought to have been an alignment of rooms of which the slab-lined cysts were a part. After the surface layer of silt was removed, a large deposit of adobe with some organic staining was uncovered. Neither features nor the edge of the deposit were found by the end of the field season. The excavations were backfilled with both the screened soil and with a distinctive, reddish-brown sand with numerous black, vesicular, vitreous inclusions measuring three to five centimeters in diameter.

As an investigation of architecture, the first campaign was a lesson in frustration. It was apparent that a new approach was necessary. However, preliminary analysis of the large collection of sherds from the surface did provide some important chronological information. While the absence of corrugated wares and painted wares with Sosi/Dogozhi designs indicated that the site was pre-A.D. 950, Black Mesa design styles indicated occupation had not been much earlier than A.D. 950.

Systematic Surface Collection

It is unrealistic to attempt to recover all materials from a site. Therefore, researchers must rely on sample collections to provide indications of prehistoric activity. Sampling is an accepted practice in anthropological (Pelto and Pelto 1970) and archaeological field research (Redman 1970, Mueller 1974).

In order to determine the extent of the site, obtain a substantial sample of the artifacts, and look for variation among areas included on the site, an extensive surface collection was undertaken in the spring of 1984. Though a smaller sample would have been acceptable, a 25

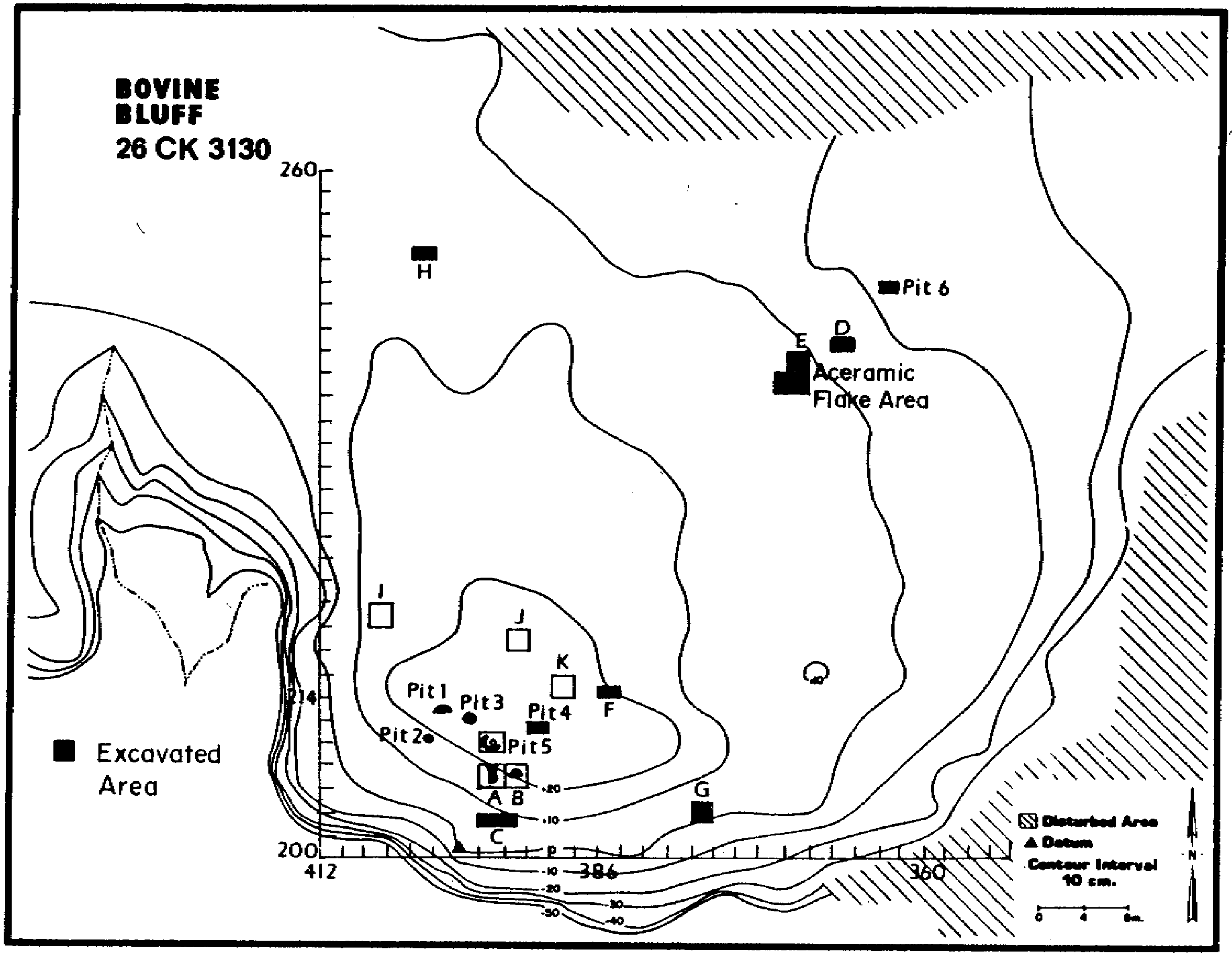

Figure 3. Map of 1983 and 1984 investigations.

percent systematic surface sample was selected for the Bovine Bluff site for two reasons. First, the site is relatively small and lacks dense vegetation making it possible to grid the site into 4 X 4 meter units with the use of string stretched along the surface. Second, Archaeo-Nevada Society volunteers were available to assist in completing the surface collection.

The sampling design provided for a 25 percent systematic sample for which the site was strung into 4 X 4 meter squares. The northwest 2 X 2 meter units were collected. Figure 4 illustrates the systematic pattern in the collection design. The grid was extended to the north, west, and east until the diminishing quantities of artifacts indicated the edges of the site. With the inclusion of the units collected during the 1983 season, 205 2 X 2 meter units constitute a 25 percent sample of the entire site north and west of 200N/352W.

A low surface density of flakes and sherds continues for approximately 100 meters east-northeast from the east border of the designated boundary line. The remains of some looted circular structures and evidence of extensive surface disturbance occur in the general area. Although no archaeological work has been done in this area, it is possible that these cultural remains are associated with occupation of the Bovine Bluff site.

During the summer of 1984, Myhrer prepared distribution maps based on the frequencies of types of artifacts in the surface collection. The distribution analysis yielded both predictable and surprising information. As expected, high frequencies of debitage and ceramics occurred on the surface above the apparent architecture and continued east along the edge of the bluff. But in the northeast section of the site where quantities of ceramics were sparse, a large number of flakes had been collected.

Based on the results of this analysis, Myhrer (1984) prepared a proposal to guide the fall 1984 investigations. The proposal was concerned with the relationship between quantities of surface and subsurface materials in several areas of the site. Dense concentrations of artifacts were expected to indicate evidence of subsurface cultural activity. The predictive capactity was not concerned with individual units but with a more general association between the surface and subsurface areas of the site. The research design permitted the investigation of undisturbed deposits in several areas of the site.

Fall 1984 Investiations

Beginning on October 13, 1984, seven Saturdays were devoted to investigations. The goals for the 1984 field season were to investigate three new areas of the site and to continue excavation of the adobe-walled room with the firepit in the center. Six 1 X 2 meter units were opened to test the predictive capacity of the surface collection distribution maps. In accordance with Myhrer's proposal (1984), they were placed judgmentally in areas of the site indicated by

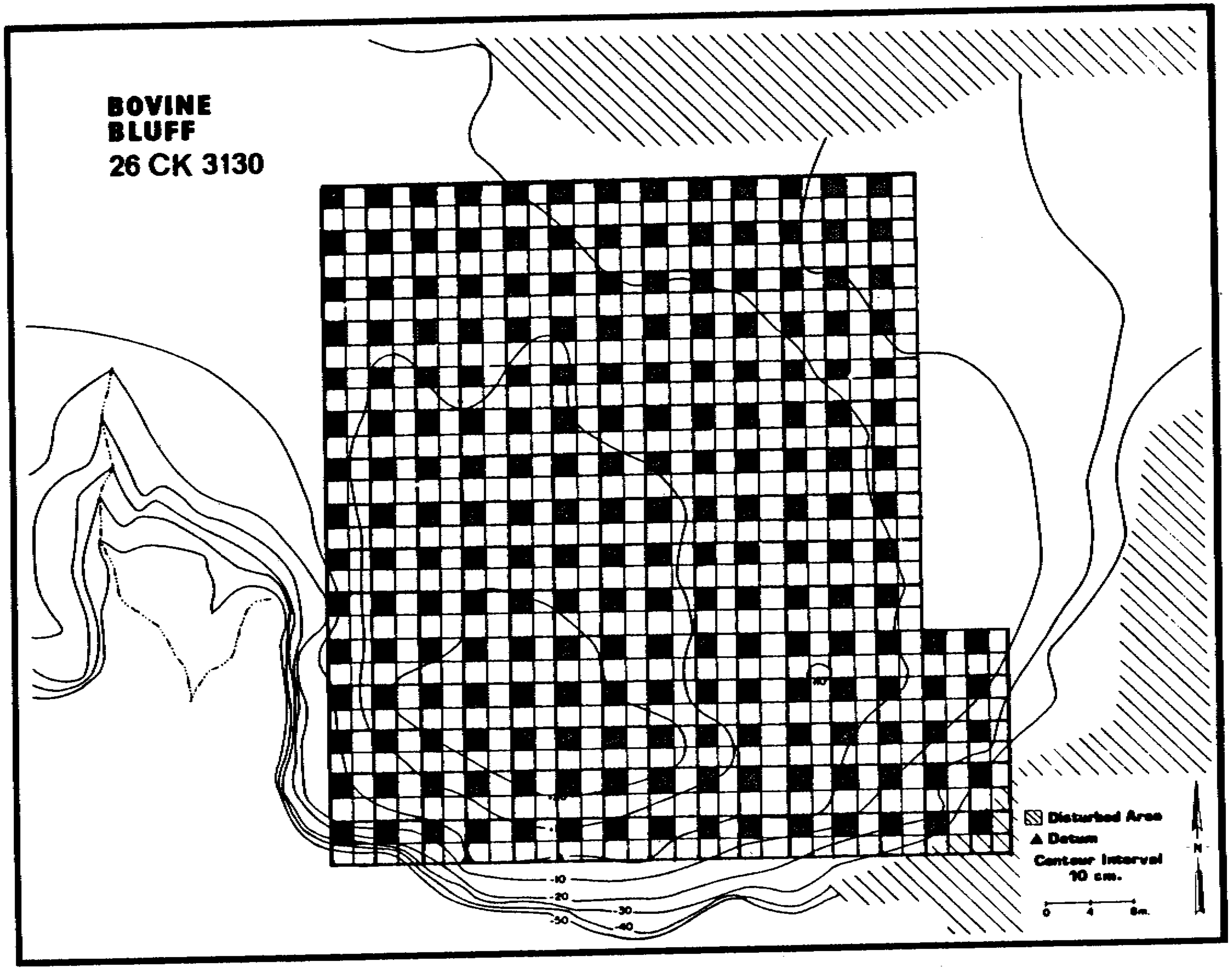

Figure 4. Map of 25 percent systematic surface collection.

the maps to contain varying quantities of lithic and ceramic refuse. No units were placed in the disturbed core of the site.

Surface collection was limited to uncollected squares about to undergo excavation and to adjacent units that would suffer surface disturbance. With the inclusion of the squares collected during fall 1984, the total number of squares collected on the site was 289, or 35 percent of the surface area.

Two units were placed in the northeast area of the site, called the aceramic flake area hereinafter, where the presence of a heavy concentration of flakes contrasted with an absence of sherds. Because excavation to 15 centimeters in one unit of the aceramic flake area (Figure 3-D) yielded little subsurface material, a pit was cut 25 centimeters into the substrate to provide a soil profile for this area of the site. In contrast, excavation in a second unit (Figure 3-E) revealed an organic-stained surface six to eight centimeters below datum. Here, the soil yielded numerous flakes. The excavation was expanded around this unit and it proved possible to trace the stained surface. On the next to the last day of excavation, a 1 X 1 meter square within this area of expansion was excavated to a deeper level. Below the stained organic-surface the soil appeared to be substantially darker, especially in comparison to the bleached silt and soil natural to the site. The screened deposit yielded numerous flakes to 20 centimeters, at which depth the end of the season halted the excavations. It is apparent that a midden of some sort lies beneath the surface concentration of flakes.

Pit 6 (Figure 3) adjoined the aceramic flake area and was excavated to investigate a round, cleared depression which was lined on one edge by fragments of a sandstone millingstone. The depression was sectioned, but neither cultural features nor artifacts were found below the surface. There were no indications that this depression was associated with the remains of a structure.

Two 1 X 2 meter units were located in an undisturbed portion of the primary concentration of sherds near the edge of the bluff. Excavation to a depth of 10 centimeters below datum in unit 214N/386W (Figure 3-F) produced large quantities of flakes and sherds and a few tools. While the cultural deposits had not been depleted at the end of the level, there were no indications that this unit was within or adjacent to architectural remains.

Excavation below the vesicular A horizon in unit 204N/378W (Figure 3-G) revealed a massive block of undisturbed adobe over much of the unit with an alignment of cobbles and resistant adobe cutting diagonally across the exposure. It seems apparent that the unit is within or in close proximity to a structure. A larger exposure will be required for investigation of this feature.

In order to better evaluate the surface/subsurface hypothesis, it was necessary to excavate a test unit in an area of the site where no artifacts had been found. Comparisons of the frequency maps revealed such an area in the northwest corner of the site. Unit 253N/402W

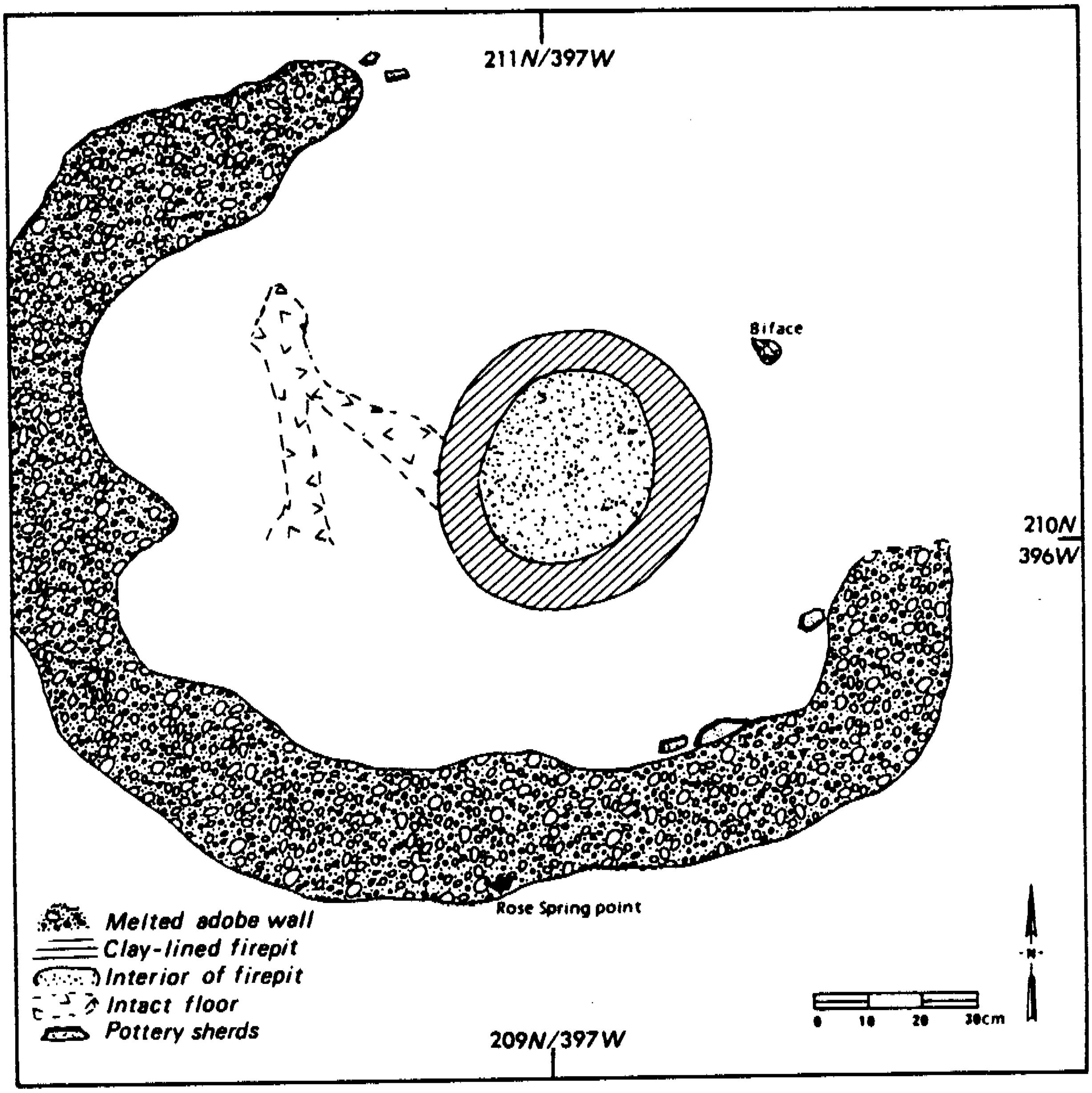

Figure 5. Plan view of Pit 5.

(Figure 3-H) was excavated to 30 centimeters below datum producing neither artifacts nor indications of features. Myhrer (1985) concluded that the absence of subsurface artifacts in this area and the presence of subsurface features and artifacts in areas where concentrations of artifacts occur on the surface confirmed the surface/subsurface hypothesis at Bovine Bluff.

Additional excavation units expandcd those of the 1983 season to expose the apparent floor and wall that curved around the rimmed firepit in Pit 5. Figure 3 provides the location of Pit 5. Figure 5 depicts the plan view of the associated excavation units. In the northeast unit, 210N/398W, the floor and rim could not be found, but were replaced by laminated fill exhibiting well-developed, water-deposited mud cracks. It is possible the northeast quadrant of this structure had been destroyed by the vandals who disturbed the site.

The 1984 excavations were backfilled with the screened soil and some very fine, clean, white quartz sand which had been dumped near the site. Plastic was used to cover the excavated units before backfilling to provide a marker of the depth of excavation for future work. Because direct contact of plastic with adobe can accelerate deterioration of the structure, sand was used to cover the excavated surfaces in 204N/378W and Pit 5 before plastic was laid.

Although it was surprising to discover the possibility of an Archaic deposit in the northwest section of the site, there is also evidence of Paiute activity. The location of a small (20 X 20 centimeters) test hole with indications of cultural activity is spatially associated with two Cottonwood Series projectile points in the vicinity of unit 220N/406W (Figure 3-I).

CERAMIC ANALYSIS

Classification of pottery from the Moapa Valley has traditionally been based on Colton's typological classification, published in 1952, for ceramics from the Arizona Strip, southeastern Utah, and southern Nevada. Several problems with the use of this typology for Moapa Valley pottery have become apparent as more research with the Virgin Anasazi has been conducted. Shutler (1961) could not match all the sherds from the Lost City collection with Colton's typology. Olson (1978) also discovered many sherds not represented in Colton's type descriptions.

Reasons for the inadequacy of Colton's (1952) typology for the Moapa Valley pottery include the limited size and variety of his sample. Colton (1952:13) based his types on limited numbers of sherds from the type collection in the Museum of Northern Arizona. Colton's methods of analysis were also limited by the technology of his time. For instance, Olson (1978:11) observes that "analysis with a 10 power lens (such as was used by Colton) can often result in far different conclusions than from analysis with a binocular microscope."

Some of the problems inherent in the classification of Moapa Valley pottery have been addressed by UNLV graduate students. Using attribute analysis, Olson (1978) noted that dark grayware with quartz temper increased through time while light grayware with olivine temper decreased. Jenkins' (1981) analysis of surface sherds from the Virgin River Valley confirmed Olson's correlation between quartz and olivine tempers and surface color.

The analysis of the Bovine Bluff ceramics is based on the 25 percent systematic surface collection. Examination of the sherds was accomplished with a forty power (40X) binocular microscope.

Classification of the Ceramics by Colton's Typology

Colton and Hargrave (1937) and Colton (1952) used combinations of attributes to establish pottery wares and types. Temper was used as one primary attribute. Three major types of temper dominate in the lower Virgin area: quartz with varying amounts of sand, olivine, and limestone.

During the ceramic analysis, ranges of variation within temper groups were noted. For example, the percentage of well-sorted rounded quartz grains in sand temper ranged on a continuum from almost 100 percent to less than 50 percent. Rather than splitting the type categories to explain each subtle change within a temper group, the classification of the pottery used in this research is guided by three assumptions. First, most of the pottery at a site will have been locally made, in this case in the Moapa Valley. Second, there will be a range of variation in the percentages of the amounts and sources of temper material from one firing to the next. Third, pottery types from other areas or regions are indeed different and, with a large enough sample from a site, non-local sherds can be reasonably detected.

Logandale Gray Ware. Colton (1952:83) describes Logandale Gray Ware, tempered with crushed limestone, as "...quite the poorest pottery made in the Southwest, because the chemical properties of the calcite in the temper make the paste very crumbling." Only one type is known, Logandale Gray. When diluted HCl is dropped on a fresh break of the sherd the limestone in the temper rapidly fizzles and dissolves. All sherds with calcite or limestone temper in the sample from Bovine Bluff are classified as Logandale Gray.

Moapa Gray Ware. The glassy appearance of the olivine and iddingsite temper is unmistakable under the binocular microscope. Seven types of Moapa Gray Ware were recognized by Colton (1952:67-82). The differences between Boulder Gray and Moapa Brown are primarily a core color of light gray with a surface color of gray for Boulder Gray and a core color of dark gray with a brownish surface color for Moapa Brown. The plain olivine/iddingsite tempered sherds in the sample from Bovine Bluff are classified as Boulder Gray. There are few differences among the decorated types in Moapa Gray Ware. Trumbull Black-on-gray exhibits wide lines and Black Mesa style decorations. Boulder Black-on-gray exhibits medium lines. The decorated olivine-tempered sherds from the sample at Bovine Bluff are classified as Trumbull Black-on-gray.

North Creek Gray Ware. Colton (1952:19) describes the temper of North Creek Gray of the Virgin Series of Tusayan Gray Ware as "predominantly abundant fine quartz sand with opaque fragments, gray, black, tan or reddish, noticeable also." Such a seemingly wide range of quartz sand varieties can make some workers uncomfortable.

Jenkins (1981:37) established a series of twelve variants of North Creek Gray. Though they placed well in his tests of seriation, Jenkins admits that "most of them were almost site-specific in distribution and were found only in minute numbers in nearby sites." Using the assumptions of mostly local manufacture and an expected degree of variation in sand temper even within sites, it seems unnecessary and even complicating to break North Creek Gray into subtypes. Plain sherds with quartz/sand temper in the sample from Bovine Bluff are classified as North Creek Gray and North Creek Fugitive Red. Decorated sherds are classified as North Creek Black-on-gray. Figure 6 illustrates several black-on-gray designs on sherds from Bovine Bluff.

San Juan Red Ware. A small percentage of redware is represented in the collection from Bovine Bluff. Colton (1952:87) describes the differences between San Juan Red Ware and Tsegi Orange Ware as being the presence of rock or sand temper and the absence of a slip on San Juan Red Ware while Tsegi Orange Ware has sherd temper and is slipped. Sherds in this collection exhibited sand temper with and without slip. Since Colton (1952:89) mentions that "Deadman's Black-on-red and Middleton Black-on-red are the only ones that have been found in the

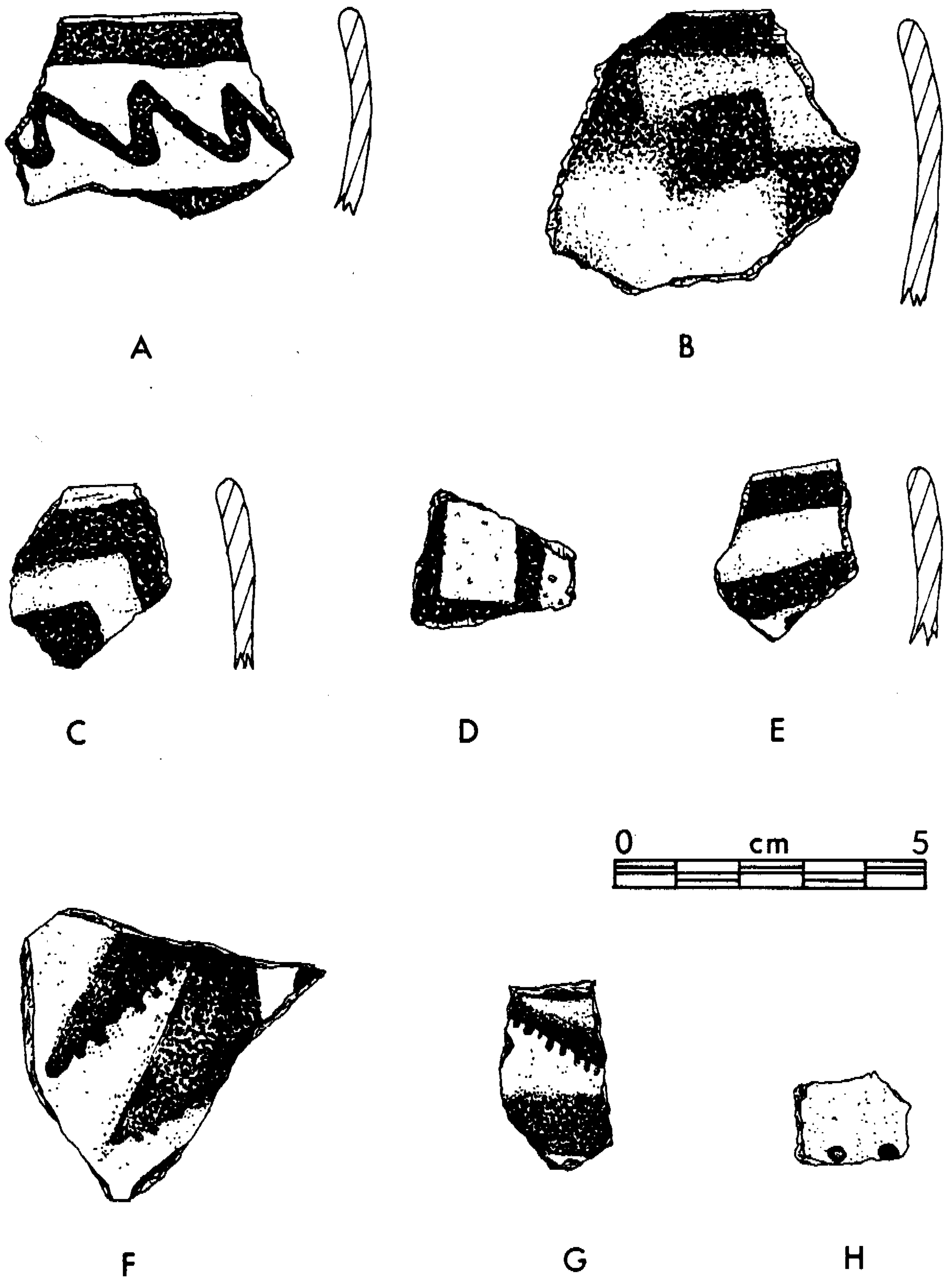

Figure 6. Black-on-gray ceramic designs. A, zig-zag line (A201-573); B, solid diamond (A201-536), C-E, medium to wide lines ((A201-739, 548, 536); F-G, pendant dots ((A201-535, 710); H, dots (A201-753).

Table 1. Temporal Ordering of Pottery Types According to Colton (1952)

Logandale Gray	Basketmaker III & Pueblo II
Boulder Gray	Basketmaker III or Pueblo I
Trumbull Black-on-gray	Pueblo II
North Creek Gray	Pueblo II - Pueblo III
North Creek Fugitive Red	Pueblo II - Pueblo III
North Creek Black-on-gray	Pueblo II (middle)
San Juan Red Ware	Pueblo I - Pueblo III (early)

Table 2. Distribution of Pottery Types at Bovine Bluff

Temper	Ware & Type	Quantity	(Percent)	Weight	(Percent)
Limestone	Logandale Gray Ware				
	Logandale Gray	1366	(57.4)	3,094.8 g.	(62.2)
	Decorated	4	(.2)	11.0 g.	(.2)
	Plain Handles	2	(.1)	13.5 g.	(.3)
	TOTAL	1372	(57.7)	3,119.3 g.	(62.7)
Olivine	Moapa Gray Ware				
	Boulder Gray	196	(8.2)	388.8 g.	(7.8)
	(Fugitive Red)	1	(.1)	2.0 g.	(.1)
	Trumbull B/G	30	(1.3)	57.7 g.	(1.1)
	(Fugitive Red)	10	(.4)	19.3 g.	(.4)
	TOTAL	237	(10.0)	468.5 g.	(9.4)
Sand	North Creek Gray Ware				
	North Creek Gray	630	(26.5)	1,106.5 g.	(22.2)
	North Creek Fugitive Red	2	(.1)	3.5 g.	(.1)
	North Creek B/G	118	(4.9)	240.7 g.	(4.8)
	(Fugitive Red)	10	(.4)	20.0 g.	(.4)
	Plain Handles	1	(.1)	4.1 g.	(.1)
	Plain Worked Sherds	2	(.1)	1.4 g.	(.1)
	TOTAL	763	(32.1)	1,376.2 g.	(27.7)
Sand	San Juan Red Ware				
	Undetermined	5	(.2)	10.0 g.	(.2)
	TOTAL	5	(.2)	10.0 g.	(.2)
GRAND TOTALS		2377	(100.0)	4,974.0 g.	(100.0)

area covered by this paper," the red sherds in this collection will be classified as San Juan Red Ware. Table 1 provides a temporal ordering of pottery types at Bovine Bluff.

The quantitative distribution of pottery types at Bovine Bluff is listed in Table 2. Logandale Gray is the dominant ware representing 58 percent of the total sherds. North Creek Gray represents 32 percent and Moapa Gray Ware represents 10 percent of the collection. In contrast, less than one percent of the decorated pottery is Logandale Gray, 13 percent is Moapa Gray, and 17 percent is North Creek Gray Ware. Ten of the 13 sherds with Fugitive Red stain are decorated.

Spatial Distribution of Pottery Tempers

An analysis of the spatial distribution of ceramic types was undertaken to help explain the apparent distinctiveness of each pottery temper. Three-dimensional graphic representations were created to illustrate the spatial distribution of the three separate pottery tempers at Bovine Bluff (Figures 7, 8, and 9). Although there appears to be little difference among the spatial distributions of the limestone-, sand- and olivine-tempered pottery, three observations about the distribution of the total quantities of pottery can be made.

First, the quantity of sherds increases from west to east along the south edge of the bluff. This is interesting because the architecture in the disturbed area of the site is located in the southwest section (see Figure 3, Pits 1-5, and A through C). It is possible that the building of structures may have begun along the east edge of the bluff and spread to the presently disturbed area. The increasing quantities from west to east may then represent the ceramic discard from first an earlier and then a later period of construction during which time the first structures may have been abandoned.

Second, unusually large quantities of sherds were collected in two units, 218N/394W and 214N/390W (Figure 3-J and K), two to six meters north of Pit 4. The highest bars in Figures 7 and 8 represent the quantities in the former unit. Though not the highest in Figure 9, the bar in unit 218N/394W visually stands out in relation to those for adjacent squares. It is possible that this concentration of sherds indicates a surface or subsurface midden associated with Pits 4 and 5.

Third, Figures 7, 8, and 9 graphically illustrate both the absence of sherds in the aceramic flake area in the northeast section, and the tightness of the distribution along the edge of the bluff. The evidence of such a pattern of discard is reassuring when planning future work based on surface concentrations.

Exterior Surface Color

The difference in colors among sherds is partly related to clay sources and firing technology. If the three pottery tempers in use at Bovine Bluff are related to function, a test of sherd surface color may

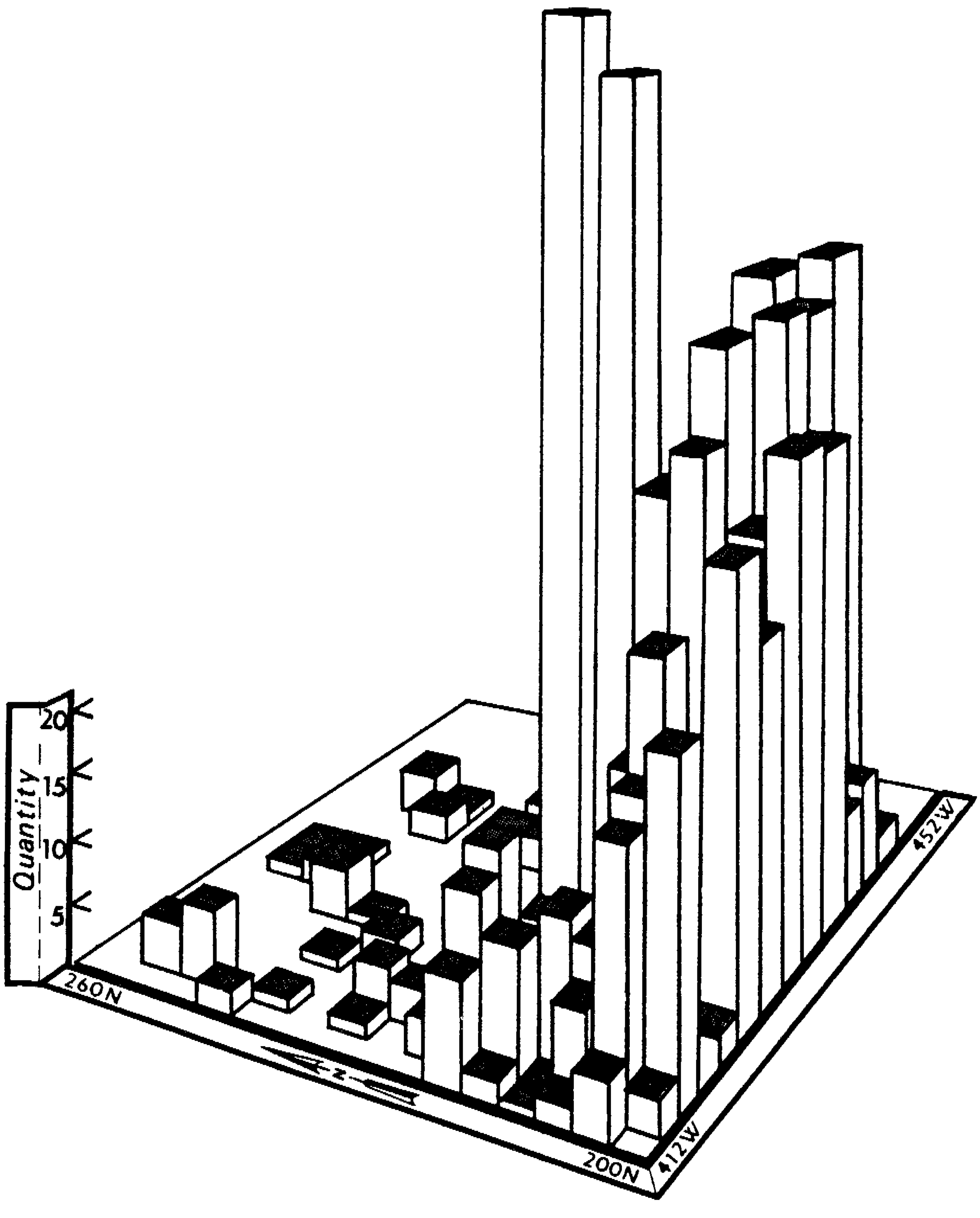

Figure 7. Three-dimensional representation of the spatial distribution of limestone-tempered pottery.

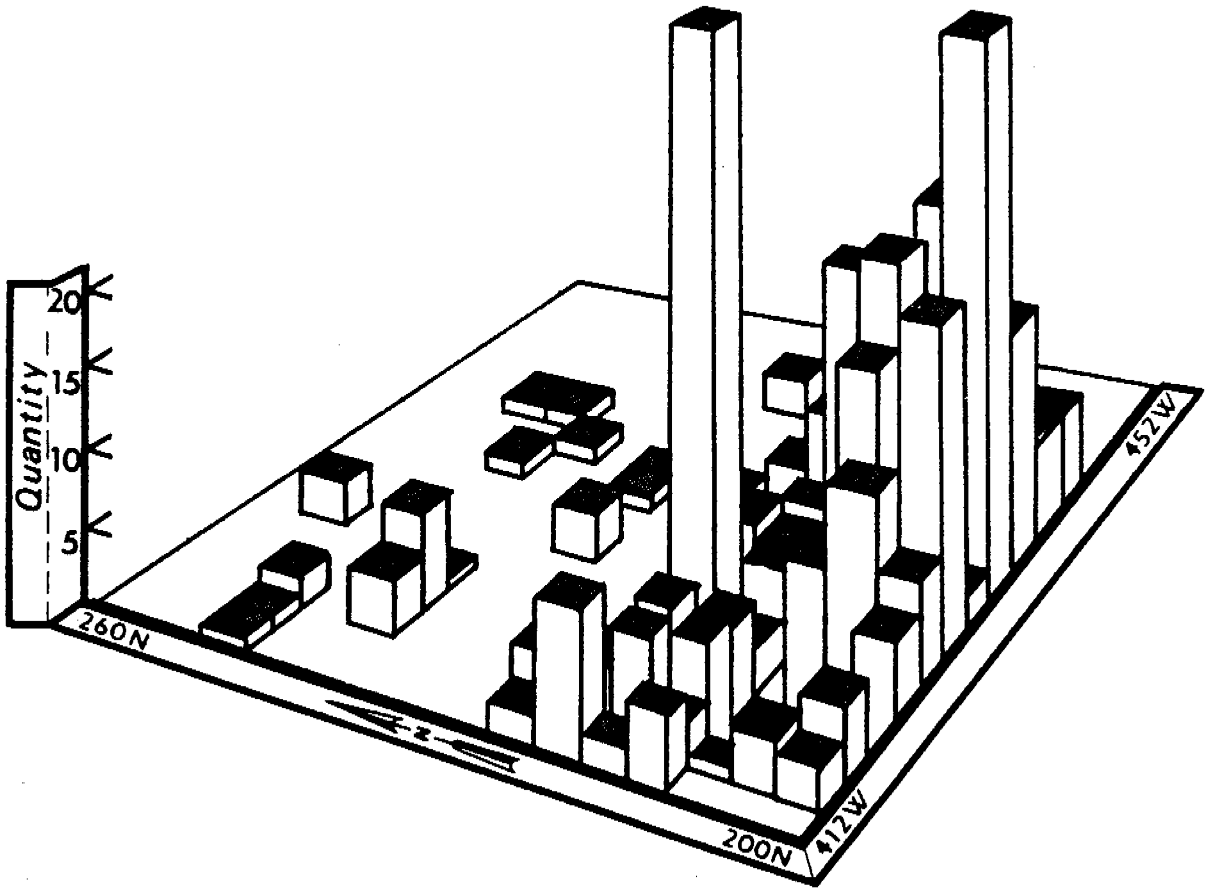

Figure 8. Three-dimensional representation of the spatial distribution of sand-tempered pottery.

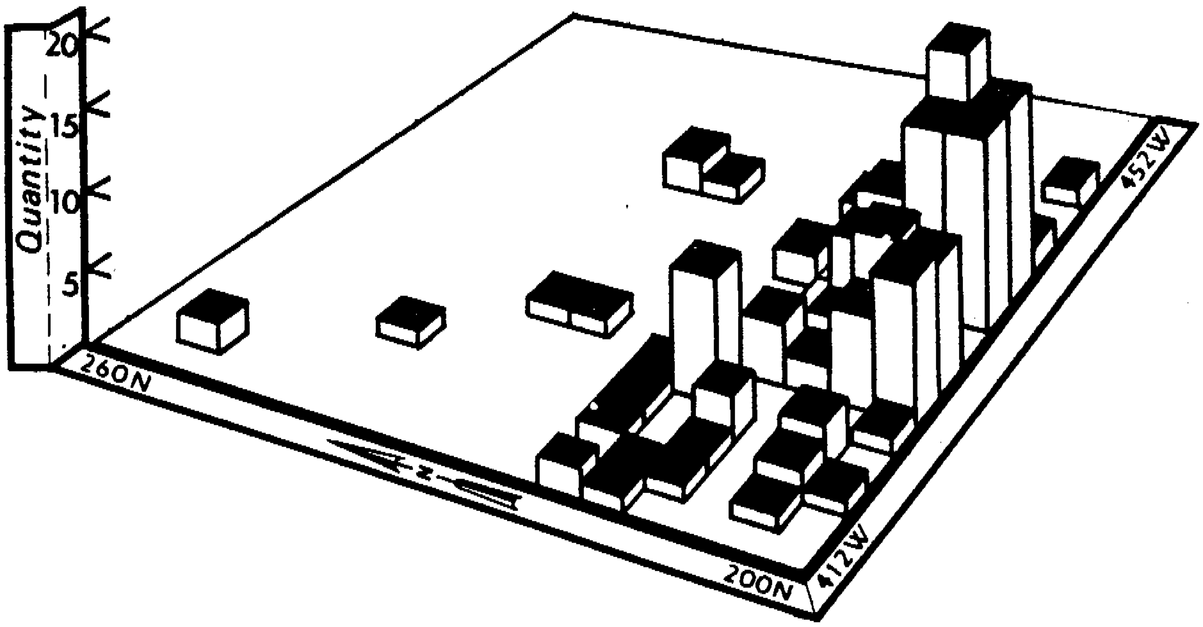

Figure 9. Three-dimensional representation of the spatial distribution of olivine-tempered pottery.

indicate more about the nature of such a relationship. The exterior surface of a 10 percent sample of plainware sherds was tested for color. The exterior color sample was obtained using the Munsell Soil Color Charts, 1975 Edition, in which color strips for each hue are mounted on 4 X 7 inch cards with 10 millimeter diameter holes adjoining each color strip. Each 10th sherd was selected. The exterior surface of the sherd was placed beneath the card and moved to cover the holes adjoining the color strips. The best color fit was noted in hue, value, and chroma.

If the 10th sherd was too small to fully cover the 10 millimeter hole the next sherd was selected. Provisions were initially made to record each color on sherds exhibiting firing clouds or other visible changes in surface color. It soon became apparent that the percentage of such sampled sherds was quite small (approximately 5 percent of the sample), and the complications of recording extra colors on such a small sample could distort the results. Therefore, a decision was made to record the color of the greatest amount of exposed surface only. In a few cases (less than 20 sherds) it was difficult to ascertain the dominant color. In those cases the next sherds were tested.

Three-dimensional representations (Figures 10, 11, and 12) were created to illustrate the quantitative range of variation of the exterior Munsell colors on the sherds at Bovine Bluff. The three highest bars in Figure 10 (limestone-tempered pottery) respectively represent Munsell colors pale brown (10YR 6/3), light brownish gray (10YR 6/2), and grayish brown (10YR 5/2). This gray-brown concentration presents a peak from which most of the colors grade. The color range of the entire sample of limestone-tempered sherds is also extremely limited.

While the range of the largest quantity of colors in the sand-tempered pottery (Figure 11) is in a block similar to that of the limestone tempered, there exists no distinct domination of two or three color units. Also, there is a notable percentage of outlier colors.

The largest block of colors of olivine-tempered pottery (Figure 12) contrasts markedly with that of the sand- and limestone-tempered sherds. There is a shift to more gray and less brown. The range of variation in the outlier colors is similar to that of the sand-tempered ware.

In summary, the three-demensional representations indicate two areas of contrast. First, there is a shift from a heavy brown concentration in the limestone tempered, to a gray-brown in the sand tempered, to a gray/light gray dominance in the olivine-tempered ware. This would support Olson's (1978) determination that light grayware with olivine temper decreased while dark grayware with quartz temper increased through time.

Second, while the range of color variation is limited in the limestone-tempered sherds, both the sand- and olivine-tempered pottery exhibit numerous outlier colors. The contrast in the amount of variation in each temper group can at least partially be attributed to differences in firing technology and clay and temper sources. In

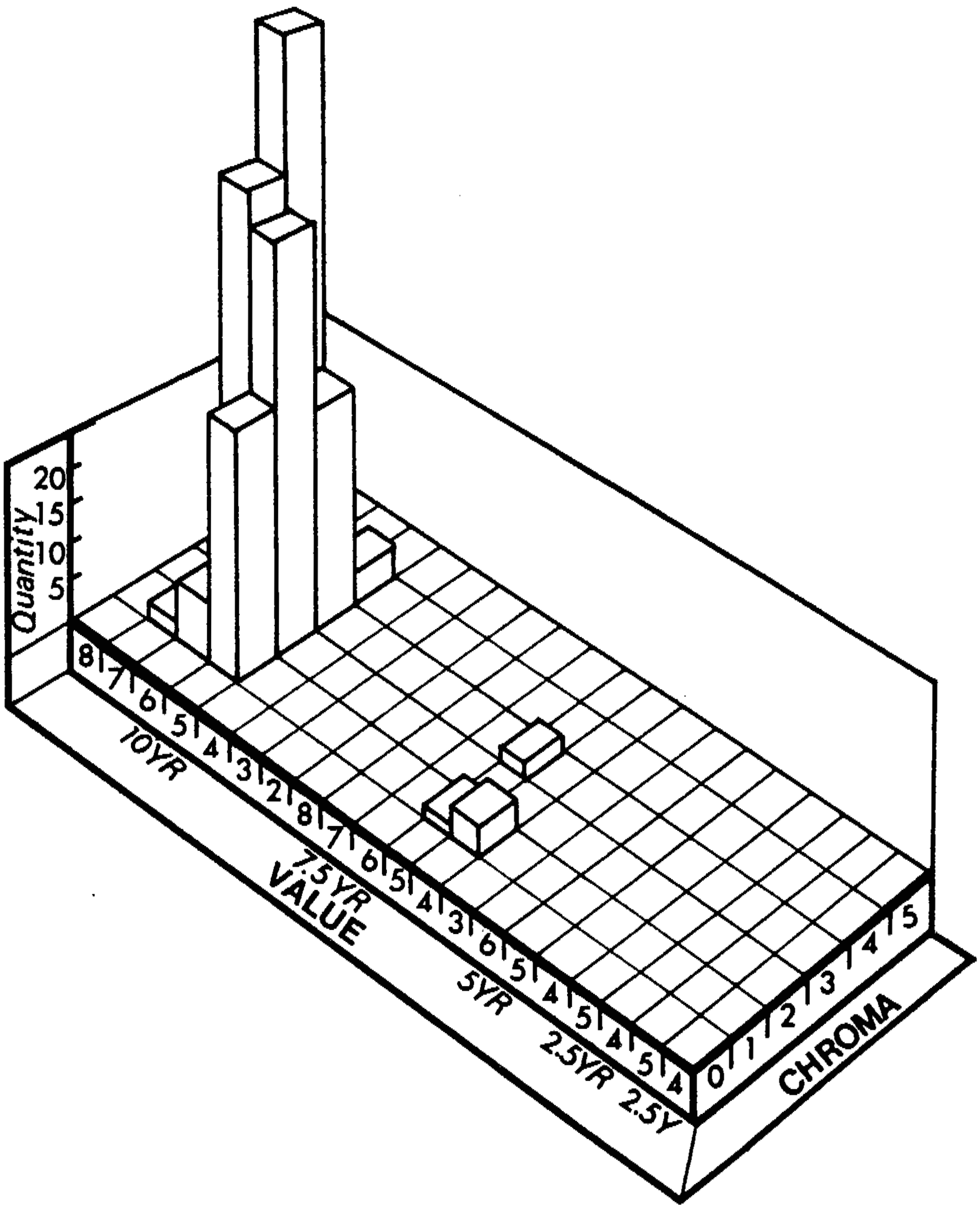

Figure 10. Three dimensional representation of the distribution of limestone-tempered sherd exterior Munsell colors.

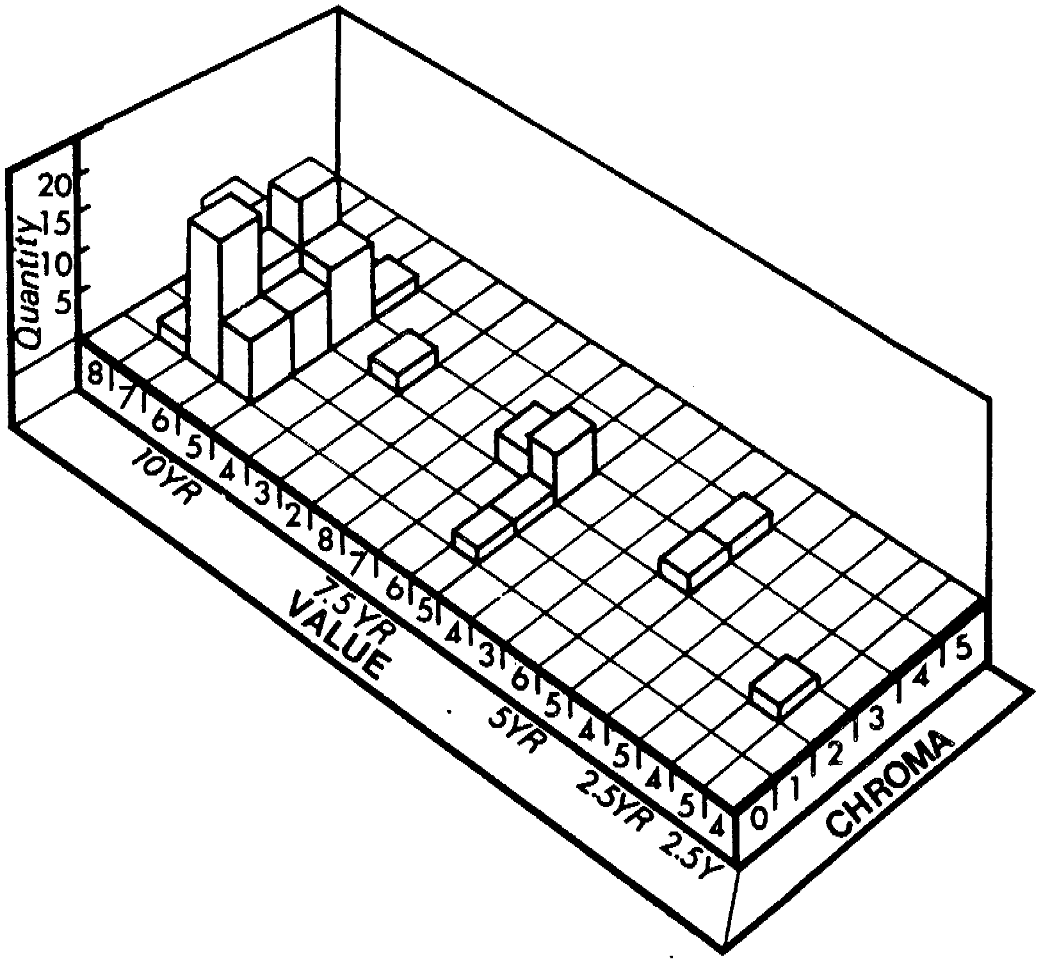

Figure 11. Three dimensional representation of the distribution of sand-tempered sherd exterior Munsell colors.

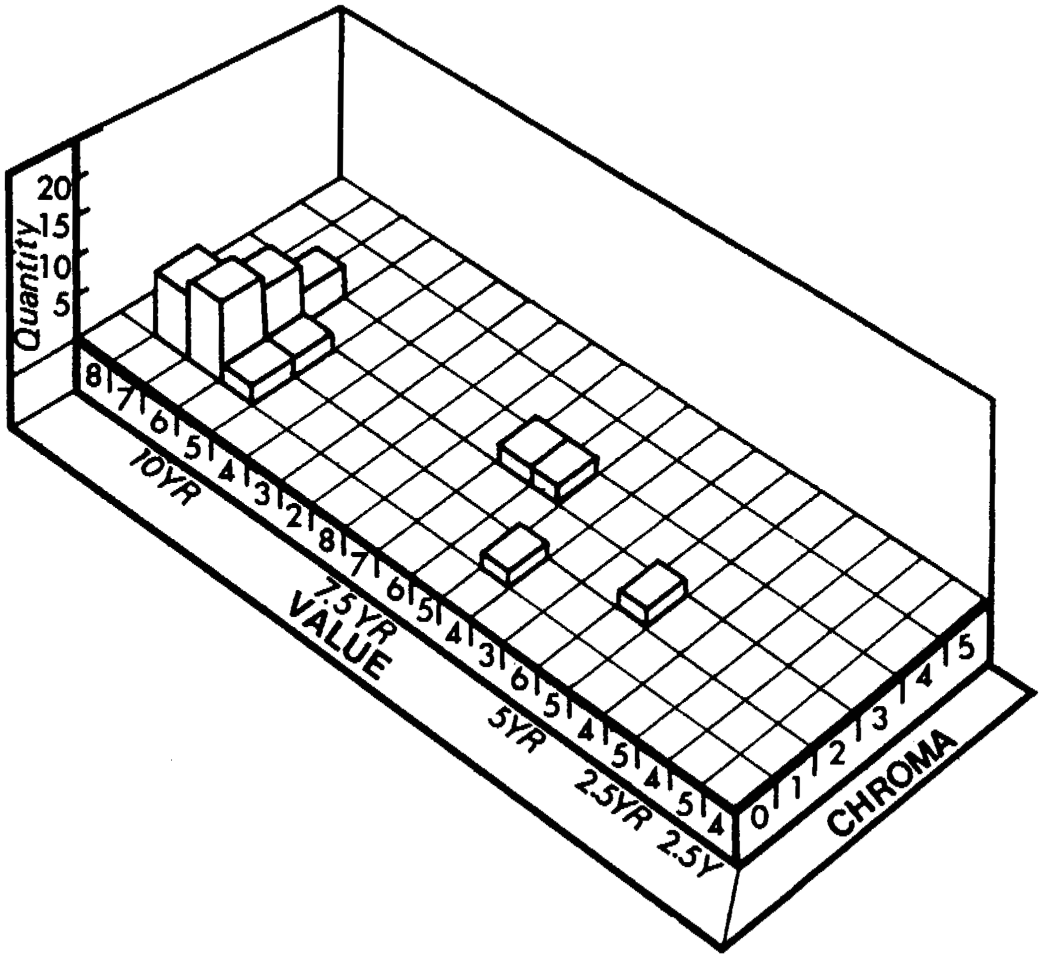

Figure 12. Three dimensional representation of the distribution of olivine-tempered sherd exterior Munsell colors.

contrast to the North Creek Gray and Moapa Gray Ware, the color representations appear to indicate a more homogenous ceramic technology for the Logandale Gray Ware.

Orifice Diameter Size

Recent studies of ceramic technologies have proven the utility in analyzing variables in addition to those discussed above. For example, in work with Black Mesa pottery, Lerner (1984) found that vessel function and orifice size were useful variables. In research with Mississippian pottery, Shapiro (1984) determined that orifice diameter sizes of bowls and jars were related to population density and site permanence. The recording of vessel function and the measurement of orifice diameter were chosen as useful variables for the analysis of the Bovine Bluff ceramics.

In order to obtain a consistent estimation of orifice diameter size, the following method was used. The rimsherd was stood on its rim surface. Its exterior curve was traced with pencil onto white paper. If the edge of the rim was ragged as a result of manufacture, a light pencil line was subjectively traced over the drawn line to smooth out and emphasize the probable curve.

A plastic, see-through "Rim-Base Potsherd Gauge," distributed by Archaeon, was used to select the vessel's probable orifice diameter. The gauge is divided into 1 centimeter width arcs ranging from 2 to 50 centimeters. The pencil-tracing was placed behind the clear gauge. Beginning with the smallest circle-section of the gauge, the tracing was moved upward until the first possible fit was reached. The measurement in centimeters was noted. Then the tracing was moved further upward until the first improbable fit was reached. The previous even-numbered reading was recorded. The rim diameter was then recorded in even-numbered measurements as the midpoint between these two possible fits.

A correlation between the size of the remaining arc of the rim and the probability of selecting an accurate estimation of the diameter of the orifice was noted. As the diameter of the orifice increases, so does the size of the arc of the rim required in order to accurately estimate the rim-diameter from the sherd. After experimentation, some minimum lengths of the actual arc-length were noted and used to guide the measurement procedures. For rim diameters up to 20 centimeters, a minimum arc-length of 10 millimeters was required. For diameters from 20 to 30 centimeters, a minimum length of 15 millimeters, and for diameters from 30 to 40 centimeters, a minimum arc-length of 20 millimeters was necessary. Although estimations of rim diameters greater than 40 centimeters were made from arc-lengths less than 20 millimeters, the accuracy of these is questionable and the recommendation for future research is to include all estimations beyond 40 centimeters in a 40+ category.

Figures 13 and 14 illustrate the quantitative distribution of exterior orifice diameters for bowls and jars. The range in size of bowl

```
      6  8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40+


9-                      BWL
8-                      BWL
7-                   BWLBWL
6-                   BWLBWL
5-                   BWLBWL         BWL
4-           BWL   BWLBWL   BWL   BWL
3-           BWL   BWLBWLBWLBWL   BWL               BWL
2-        BWLBWL   BWLBWLBWLBWL   BWL      BWLBWLBWLBWL
1-        BWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWLBWL
```

Figure 13. Estimated Orifice Diameters (in centimeters) of Bowl Rims.

```
      6  8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40+

8-                         JAR
7-          JAR            JAR
6-          JAR            JAR
5-          JAR         JARJARJAR
4-          JAR         JARJARJAR
3-       JARJARJAR      JARJARJARJAR
2-       JARJARJAR      JARJARJARJAR   JAR
1        JARJARJARJAR   JARJARJARJARJARJAR   JAR
```

Figure 14. Estimated Orifice Diameters (in centimeters) of Jar Rims.

The high frequency of limestone-tempered pottery at Bovine Bluff argues for a local ceramic industry dominated by the manufacture of jars. The primary functions of jars are for storage of water and for cooking and storage of agricultural products. Harrington (1925:13) noted that the Virgin Anasazi "farmed the lowlands of the valley, and raised corn and beans and squashes." The emphasis on storage and cooking vessels during the Virgin Anasazi occupation at Bovine Bluff argues for a strong dependence on agriculture.

CHIPPED STONE ANALYSIS

Except for the inclusion of all projectile points, analysis of the chipped stone from Bovine Bluff is limited to materials recovered from the 25 percent surface collection. A total of 1559 pieces are included in this analysis. Due to their utility as chronological markers, all projectile points are included in the analysis.

The chipped stone was washed and catalogued by collection unit to permit an analysis of the spatial distribution of various artifact types. Pieces were then sorted by material type into major analytical categories and subcategories. Attributes such as dimension and weight were then recorded for each specimen to permit a quantitative analysis of the range of variation within a category or subcategory. The results of these analyses are presented below.

Definitions of Lithic Material Types

Skinner (1984:A-9-10) defines a series of material types that aptly describe those found in the Bovine Bluff collection. These are:

Chert: A subgroup of cryptocrystalline silicate "...formed through silica replacement or recrystallization (Skinner 1984:A-9)." Chalcedony is another subgroup of crypotcrystalline silicate containing less impurities than chert. Because chert and chalcedony are so closely related and identification can be inconsistent, both chert and chalcedony are referred to as chert.

Obsidian: "A noncrystalline natural glass that has no crystal structure because the molten magma cooled so quickly that the atoms or ions did not have time to form into regular arrangements....It is usually translucent or transparent, has a vitreous luster and a conchoidal fracture (Skinner 1984:A-9)."

Basalt: "A fine-grained and dark-colored metavolcanic rock (Skinner 1984:A-9)."

Vesicular Basalt: A basalt exhibiting air pockets formed during volcanic activity.

Rhyolite: "A fine-grained, red or purple igneous rock, the aphinitic equivalent of granite (Skinner 1984:A-9)."

Quartz: A "metamorphised sandstone...(or) silicified sandstone....medium-grained and has a less well-developed conchoidal fracture than the cryptocrystalline silicates, a vitreous luster and a sugary texture (Skinner 1984:A-10)."

Sandstone: "A cemented sediment composed mainly of quartz grains (Skinner 1984:A-10)."

Limestone: "A bedded sedimentary deposit consisting mainly of calcium carbonate, and is most often grayish-white to gray in color (Skinner 1984:A-10)."

As noted above, the chipped stone from Bovine Bluff was sorted by these material types into major analytical categories. The major categories used for the analysis of chipped stone are labelled debitage, large tools, small tools, and cores.

Debitage (N=1402)

Crabtree (1972:58) defines debitage as:

> Residual lithic material resulting from tool manufacture. Useful to determine techniques and for showing technological traits. Represents intentional and unintentional breakage of artifacts either through manufacture or function. Debitage flakes usually represent the various stages of progress of the raw material from the original form to the finished stage.

Bearden (1981:361) defines a flake as "a piece of chipped stone which has been pressure- or percussion-removed from the parent material." Skinner (1984:A11-12) provides a clear set of definitions for use in classifying the debitage material according to reduction stages. Skinner's definitions were primarily used for this research.

I. Decortication Flakes (N=342).

Those flakes first removed from a core, exhibiting 50 percent or more cortex (the outer rind) on the dorsal surface. Also, those flakes removed in an adjacent overlapping series, with less than 50 percent of the dorsal face covered with cortex.

II. Shatter (N=173).

Shatter is cubical and irregularly shaped material which lacks well-defined bulbs of force or systematic alignment of cleavage scars. Shatter is often the distal end of chunky flakes, but well-defined flake characteristics cannot be observed.

A. First Stage Shatter exhibits cortex.

B. Second Stage Shatter lacks cortex.

III. Thinning Flakes (N=508).

As the name indicates, thinning flakes imply biface thinning.

A. First Stage Thinning exhibits cortex on the dorsal face.

B. Second Stage Thinning lacks cortex.

IV. Interior Flake (N=303).

Flake scars are evident on the dorsal surface, but will not usually exhibit the patterned dorsal flake scars of a thinning flake, nor will they curve consistently at the same distance from the platform. Though no cortex is present, an interior flake implies reduction from the core rather than biface manufacture.

V. Tertiary Flake (N=76).

The flakes in this reduction class lack cortex and dorsal flake scars.

Table 4. Quantitative Distribution of Debitage by Material and Reduction Stages (Weight in Grams)

Reduction Class	Chert	Obsidian	Basalt	Material Quartz	Limestone	TOTAL	Percent
Decortication	283	6	2	42	9	342	(24.4)
Weight	2464.4	28.5	32.3	374.8	104.6	3004.6	(55.6)
Shatter							
First Stage	64	--	--	1	--	65	(4.7)
Weight	434.0	--	--	1.1	--	435.1	(8.0)
Second Stage	96	2	--	6	4	108	(7.7)
Weight	255.4	1.5	--	27.9	42.0	326.8	(6.0)
Thinning							
First Stage	36	--	--	1	--	37	(2.6)
Weight	20.8	--	--	.4	--	21.2	(0.4)
Second Stage	443	7	--	21	--	471	(33.6)
Weight	217.8	1.5	--	24.6	--	243.9	(4.5)
Interior	252	1	--	19	31	303	(21.6)
Weight	673.8	1.1	--	66.9	514.0	1255.8	(23.2)
Tertiary	56	--	--	15	5	76	(5.4)
Weight	81.0	--	--	25.7	14.7	121.4	(2.3)
Total Quantity	1230	16	2	105	49	1402	
Total Percent	(87.7)	(1.2)	(.1)	(7.5)	(3.5)	(100.0)	
Total Weight	4147.2	32.6	32.3	521.4	675.3	5408.8	
Total Percent	(76.7)	(.6)	(.6)	(9.6)	(12.5)	(100.0)	

Quantitative Distribution Analysis of Debitage. Table 4 illustrates the quantitative distribution of the debitage by material type and reduction stage. Eighty-eight percent of the total is chert, seven percent quartz, four percent limestone, one percent obsidian, and less than one percent basalt. The greatest number of pieces are classified as first and second stage thinning flakes. However, large percentages of decortication and interior flakes are represented in the sample. This seems to imply that all stages of chert reduction took place on the site with an emphasis on the final stages of biface manufacture. This type of reduction process is expected in view of the immediate availability of chert nodules on the site.

Spatial Distribution Analysis of Debitage. Figures 15 through 19 illustrate the spatial distribution of debitage by reduction stages. In contrast to the spatial distribution of pottery, the largest quantities of debitage are centrally located along the south edge of the bluff rather than towards the west. There is not enough information at this point to account for this difference. It is interesting to note the high intensity of flakes represented in each Figure in the aceramic flake area in the northeast section of the site.

There are some spatial differences among the reduction classes. While initially laying out the grid controls for the site, a partially reduced core and several flakes of a white chert cobble were noted in the northwest area of the site. This knapping station was later collected. The large quantity of decortication flakes associated with this knapping station is illustrated by the large bar of 15 to 20 flakes in the northwest section of the map in Figure 15.

While the thinning flakes are heavily concentrated in the southeast section of the site (Figure 17), the distribution of decortication flakes (Figure 15) is more evenly spaced. Perhaps this indicates a designated section near, but outside the structural area, primarily used for biface thinning. The expected distribution of interior flakes (Figure 18), though, does not comply with this suggestion.

While not providing evidence of major spatial differences among the reduction classes, the three-dimensional distribution maps do indicate the location of areas of debitage concentration on the site. It appears that a full range of knapping activities, from the reduction of cobbles to the final thinning of bifaces, was carried out on the site. In addition, most of the knapping activity was conducted near what is indicated to have been the structural areas.

Large Tools (N=61)

This category includes chopping and battering tools. Groups within each category were defined using an estimate of differences in the amount of energy expended in the use or manufacture of each tool. The artifacts were first visually classified in terms of light to medium to heavy use, then definitions written describing the differences in each group. Next a grab sample was reexamined and compared with the written descriptions. These definitions adequately describe the differences between groups in terms of use and were basically left unchanged. Determinations of the percentages of remaining cortex were visually calculated. As such, they are subjective estimations.

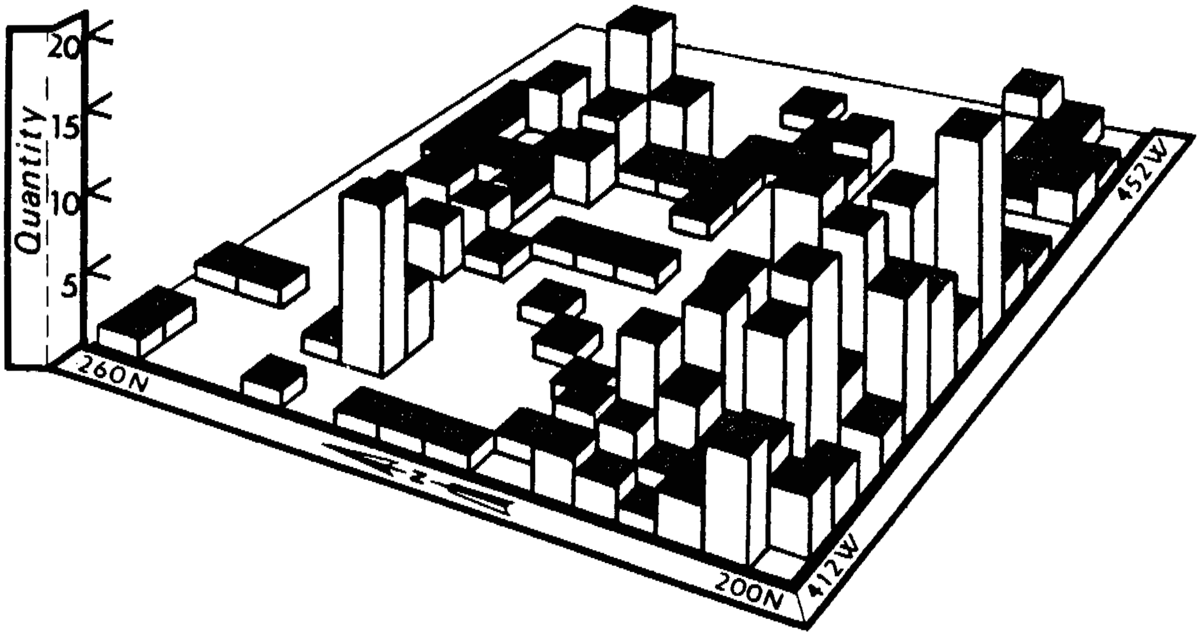

Figure 15. Three-dimensional representation of the spatial distribution of decortication flakes.

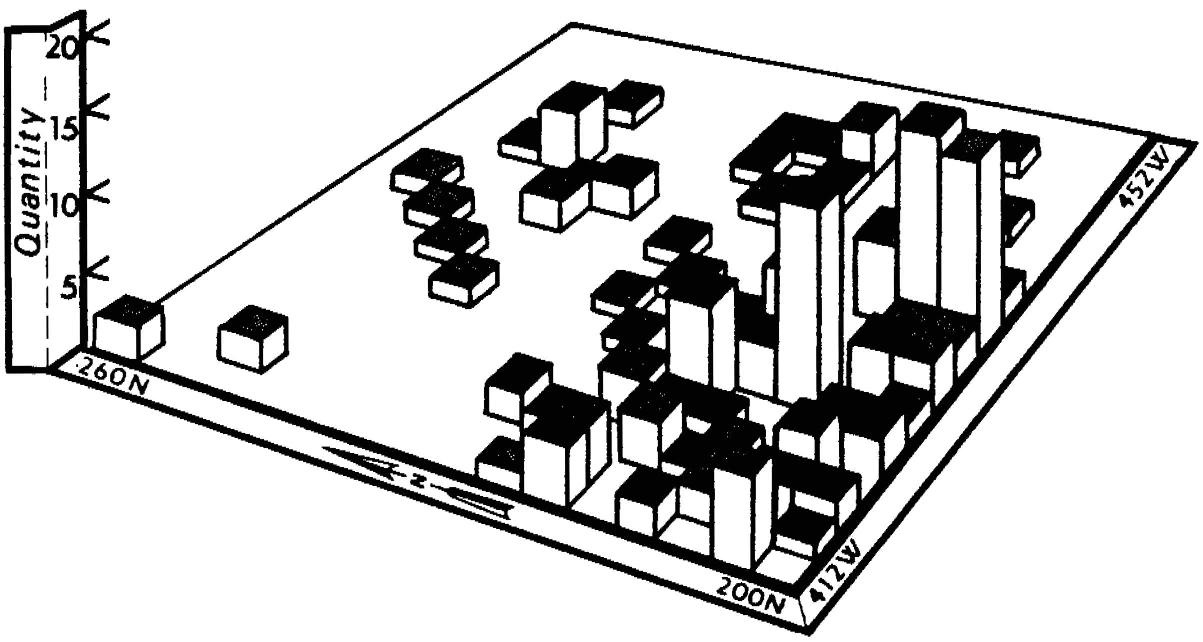

Figure 16. Three-dimensional representation of the spatial distribution of shatter flakes.

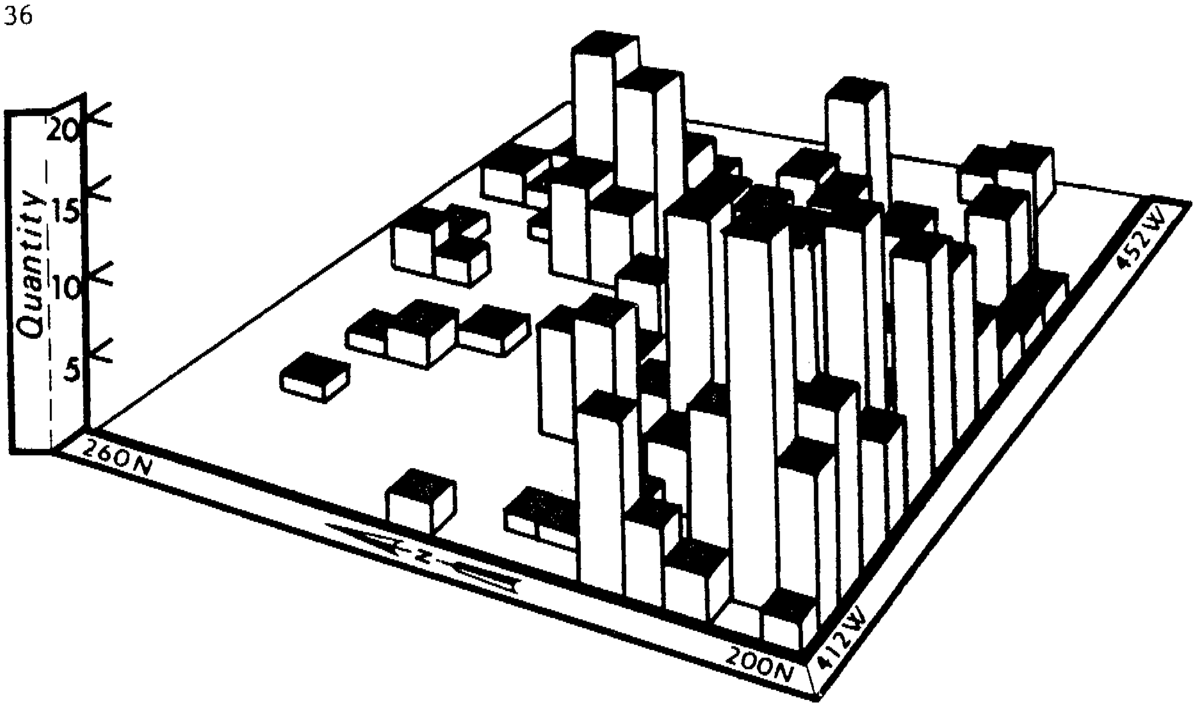

Figure 17. Three-dimensional representation of the spatial distribution of thinning flakes.

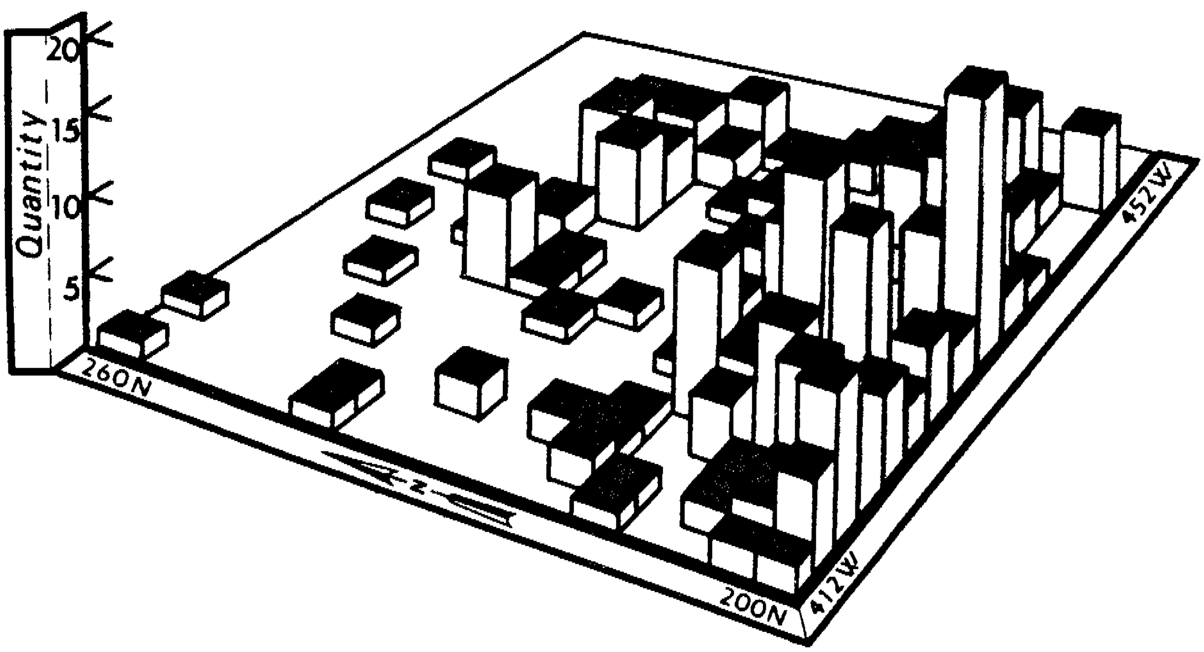

Figure 18. Three-dimensional representation of the spatial distribution of interior flakes.

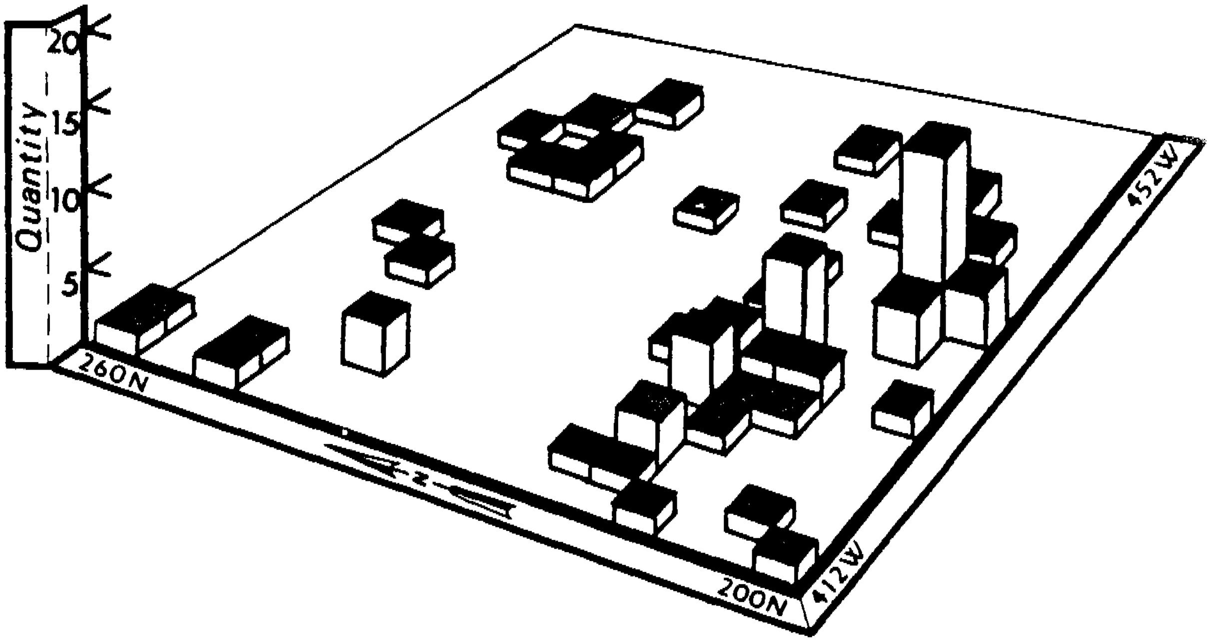

Figure 19. Three-dimensional representation of the spatial distribution of tertiary flakes.

I. Core Tool/Chopper. N=21.

Crabtree (1972:56) defines core tool as an "ambiguous term," which "...carried to its logical extreme all tools from which flakes are removed are core tools." Yet Crabtree (1972:51) subsequently describes a chopper as a "heavy core tool presumed to be used for chopping. May be uniface or biface."

For purposes of this research, a core tool is defined as a chopping tool manufactured from a cobble. Flaking is minimal producing a great variety of cross-sections and outline shapes. Since the difference between core tools and choppers appears to be primarily size, core tools and choppers are classified as one group.

Light flaking is defined as the removal of three or less flakes from a core. Medium flaking is defined as the removal of from four to eight flakes. Heavy flaking is defined as the removal of more than eight flakes.

A. Light Flaking (N=6).

All of the specimens in this category are unifacially flaked from rounded or discoidal shaped limestone cobbles. Outlines range from ovoid (3), to elongate (2), to irregular (1). Cross-sections range from lenticular (4) to plano-convex (2). The percentages of cortex remaining on the tools range from 60 to 90 with a mean of 84 percent. Table 5 lists the range of discrete measurements.

Table 5. Size Range of Core Tool/Choppers - Light Flaking

	Minimum	Maximum	Mean
Length	90.5 mm	145.0 mm	107.6 mm
Width	66.1 mm	126.8 mm	89.7 mm
Thickness	22.2 mm	54.1 mm	35.4 mm
Weight	235.7 g	1,024.5 g	505.3 g

B. Medium Flaking (N=11).

Eight tools are flaked from rounded limestone cobbles, one from a subangular limestone cobble, one from a rounded basalt cobble, and one from an angular chert cobble. Eight are unifacial and three are bifacial. Outlines range from ovoid (5), to elongate (2), to irregular (3), to triangular (1). Cross-sections range from lenticular (3), to bi-convex (3), to plano-convex (3), to triangular-plano (1), to an undetermined cross-section (1). The percentages of cortex remaining on the tools range from 35 to 90 with a mean of 74 percent. Table 6 illustrates the size ranges.

Table 6. Size Range of Core Tool/Choppers - Medium Flaking

	Minumum	Maximum	Mean
Length	78.8 mm	134.0 mm	100.7 mm
Width	52.4 mm	107.3 mm	83.5 mm
Thickness	32.2 mm	58.1 mm	41.2 mm
Weight	211.3 g	1007.6 g	457.9 g

C. Heavy Flaking (N=4).

All specimens in this category are bifacially flaked from rounded limestone cobbles. Figure 20-B is an illustration of a core tool/chopper with heavy flaking. Outlines range from ovoid (3) to irregular (1). Cross-sections range from lenticular (2), to bi-convex (1), to triangular-convex (1). The percentages of cortex remaining on the tools range from 10 to 80 with a mean of 53 percent. The size ranges are shown in Table 7.

Table 7. Size Range of Core Tool/Choppers - Heavy Flaking

	Minimum	Maximum	Mean
Length	79.0 mm	88.6 mm	85.3 mm
Width	62.4 mm	96.8 mm	76.4 mm
Thickness	31.8 mm	54.7 mm	40.7 mm
Weight	230.5 g	416.0 g	293.9 g

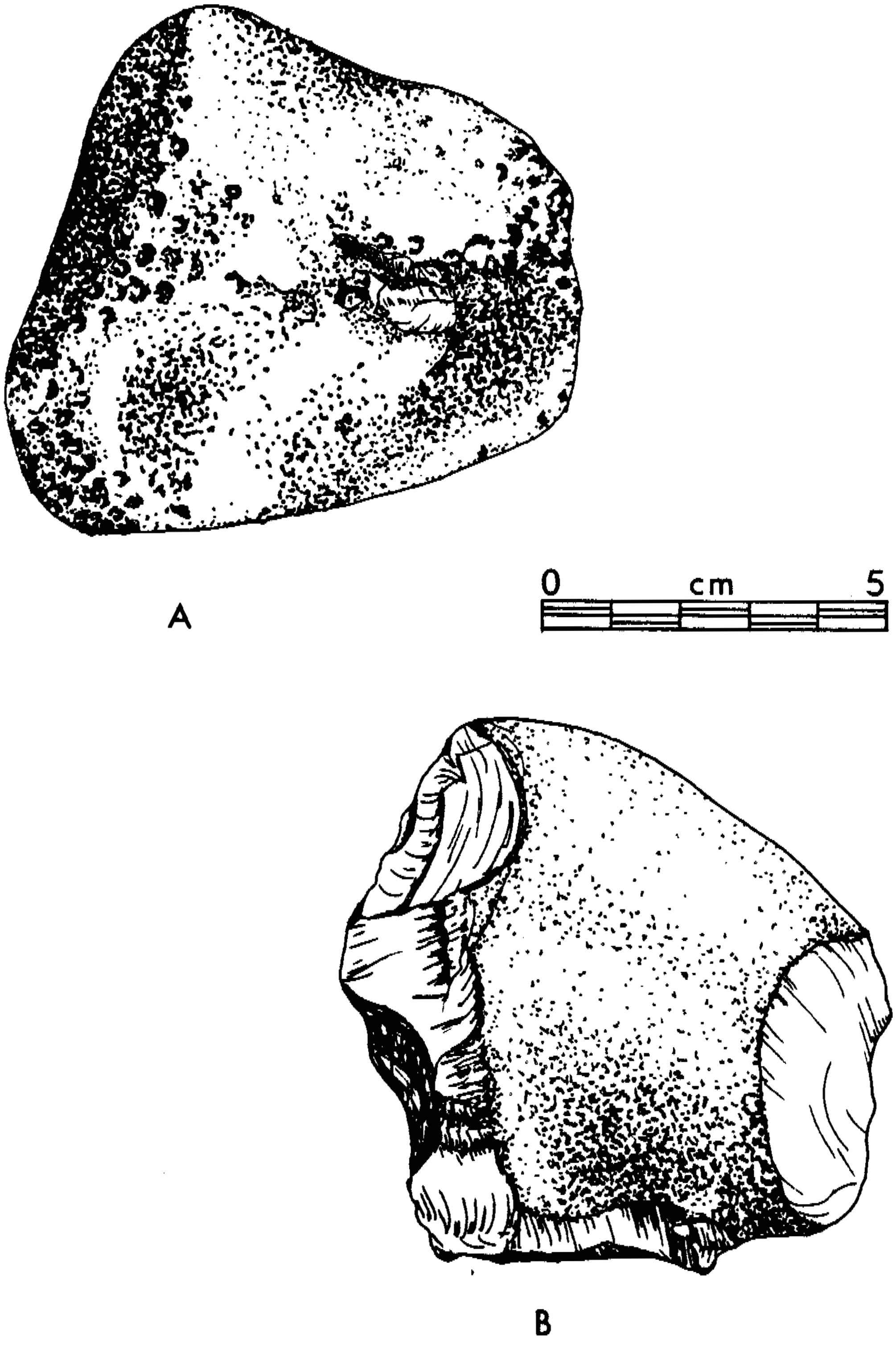

Figure 20. Large tools. A, hammerstone— heavy battering (A201-732); B, core tool/chopper - heavy flaking (A201-144).

II. Hammerstone (N=30).

A hammerstone is defined as a pebble or cobble that has been battered on the sides and/or ends (Bearden 1981:361). Light battering is defined as the evidence of less than ten battering marks on only one edge of the artifact. Medium battering is defined as the evidence of 15 or less battering marks on one or more edges of the specimen. Heavy battering is defined as evidence of more than 15 battering marks combined on more than one edge.

A certain amount of subjectivity was necessary in determining the amount of battering, expecially from medium to heavy use. If the artifact had been continuously battered on one area, an estimate of battering marks could not be accurately made. In that case, if the specimen had been battered on several edges the tool was placed into the "heavy" category. If only one edge had been battered, the tool was placed into the "medium" category.

A. Light Battering (N=11).

Four specimens are made from limestone cobbles, one from a subangular limestone cobble, five from subangular quartz cobbles, and one from an angular quartz cobble. Outlines range from ovoid (3), to elongate (3), to elongate with a pointed end (2), to irregular (1), to irregular with a pointed end (2). Cross-sections range from lenticular (2), to bi-convex (5), to bi-plano (3), to triangular-convex (1). Seven specimens are whole and four are fragmented. One of the fragmented tools has been battered on the broken edges after fragmenting. The percentages of remaining cortex range from 35 to 100 with a mean of 78 percent. Table 8 lists the range of discrete measurements.

Table 8. Size Range of Hammerstones - Light Battering

	Minimum	Maximum	Mean
Length	60.7 mm	123.8 mm	99.4 mm
Width	47.0 mm	98.0 mm	71.8 mm
Thickness	15.8 mm	76.5 mm	44.9 mm
Weight	83.1 g	1,111.4 g	450.1 g

B. Medium Battering (N=8).

One artifact is made from a rounded limestone cobble, two from rounded quartz cobbles, three from subangular quartz cobbles, one from an angular quartz cobble, and one quartz cobble is too fragmented to determine its original angularity. Three specimens are whole, and five are fragmented. Three of the fragmented objects are battered on the fragmented edges. Outlines range from ovoid (5), to elongate (2), to irregular (1). Cross-sections range from bi-convex (1), to plano-convex (1), to bi-plano (5), to triangular-plano (1). The percentages of remaining cortex range from 35 to 100 with a mean of 78 percent. Table 9 illustrates the size range of the specimens.

Table 9. Size Range of Hammerstones - Medium Battering

	Minimum	Maximum	Mean
Length	58.1 mm	122.2 mm	81.0 mm
Width	34.0 mm	110.2 mm	65.9 mm
Thickness	15.2 mm	78.0 mm	36.9 mm
Weight	68.6 g	1,326.6 g	356.1 g

C. Heavy Battering (N=11).

Seven artifacts are made from subangular quartz cobbles, three from angular quartz cobbles, and one from an angular chert cobble. Figure 20-A is an illustration of a hammerstone that has been heavily battered. Eight specimens are complete and three are fragmented. One fragmented tool has been battered on the fragmented edges. The percentages of remaining cortex range from 20 to 100 with a mean of 82 percent. Outlines range from ovoid (3), to elongate (2), to elongate with a pointed end (1), to irregular with a pointed end (4), to square (1). Cross-sections range from lenticular (2), to bi-convex (2), to plano-convex (1), to bi-plano (6). The range of discrete measurements is listed in Table 10.

Table 10. Size Range of Hammerstones - Heavy Battering

	Minimum	Maximum	Mean
Length	69.5 mm	129.5 mm	95.7 mm
Width	55.3 mm	98.1 mm	76.3 mm
Thickness	44.3 mm	67.5 mm	51.8 mm
Weight	254.3 g	808.5 g	458.5 g

III. Core Tool/Chopper - Hammerstone (N=9).

A visual continuum between the core tool/chopper category and the hammerstone category was clearly demonstrated in the Bovine Bluff collection. Specimens in this category have both been flaked and battered to varying extents.

Three artifacts are classified as light unifacial flaking and light battering. One specimen in this subcategory has been made from a subangular limestone cobble and two have been made from angular quartz cobbles. One artifact, classified as medium unifacial flaking and light battering, is made from a subangular limestone cobble. Another specimen, made from an angular chert cobble, is classified as medium unifacial flaking and medium battering.

Two specimens are classified as medium bifacial flaking and medium battering. One has been made from an angular quartz cobble, the other from a rounded limestone cobble. One artifact, illustrated in Figure 21-A, is classified as heavy bifacially flaked and medium battered It is made from an angular quartz cobble. Another specimen, classified as heavy bifacially flaked and heavy battered, is made from a subangular quartz cobble.

Outlines of the specimens in the core tool/chopper - hammerstone category range from ovoid (3), to elongate (1), to elongate with a pointed end (1), to irregular (4). Cross-sections range from bi-convex (3), to plano-convex (4), to bi-plano (1), to triangular-plano (1). The percentages of remaining cortex range from 50 to 85 with a mean of 68 percent. Table 11 illustrates the range of discrete measurements for these tools.

Table 11. Size Range of Core Tool/Chopper - Hammerstones

	Mimimum	Maximum	Mean
Length	65.6 mm	146.0 mm	91.5 mm
Width	36.5 mm	111.5 mm	68.8 mm
Thickness	31.9 mm	58.5 mm	44.5 mm
Weight	94.9 g	1,394.4 g	440.5 g

IV. Hammerstone Flake. N=1.

One decortication quartz flake exhibits a substantial amount of battering on its dorsal surface. Its weight is 29.9 grams.

Small Tools (N=85)

The small tool category is comprised of small, flaked implements for use in hunting, cutting, and drilling. The tools may have been utilized. Definitions for this category were developed from Bearden (1981:361).

I. Unifacial (N=20).

A. Scraper (N=8).

A scraper is a flake, blade, or piece of shatter that has been marginally chipped along one side to produce a steep edge. Four specimens are made from chert, one limestone, one rhyolite, and one obsidian. Figure 22-C illustrates a chert scraper. Outlines range from ovoid (1), to elongate (2), to irregular (4). Cross-sections range from lenticular (3) to plano-convex (5). The percentages of remaining cortex range from 0 to 45 with a mean of 32 percent. Table 12 lists the range of discrete measurements.

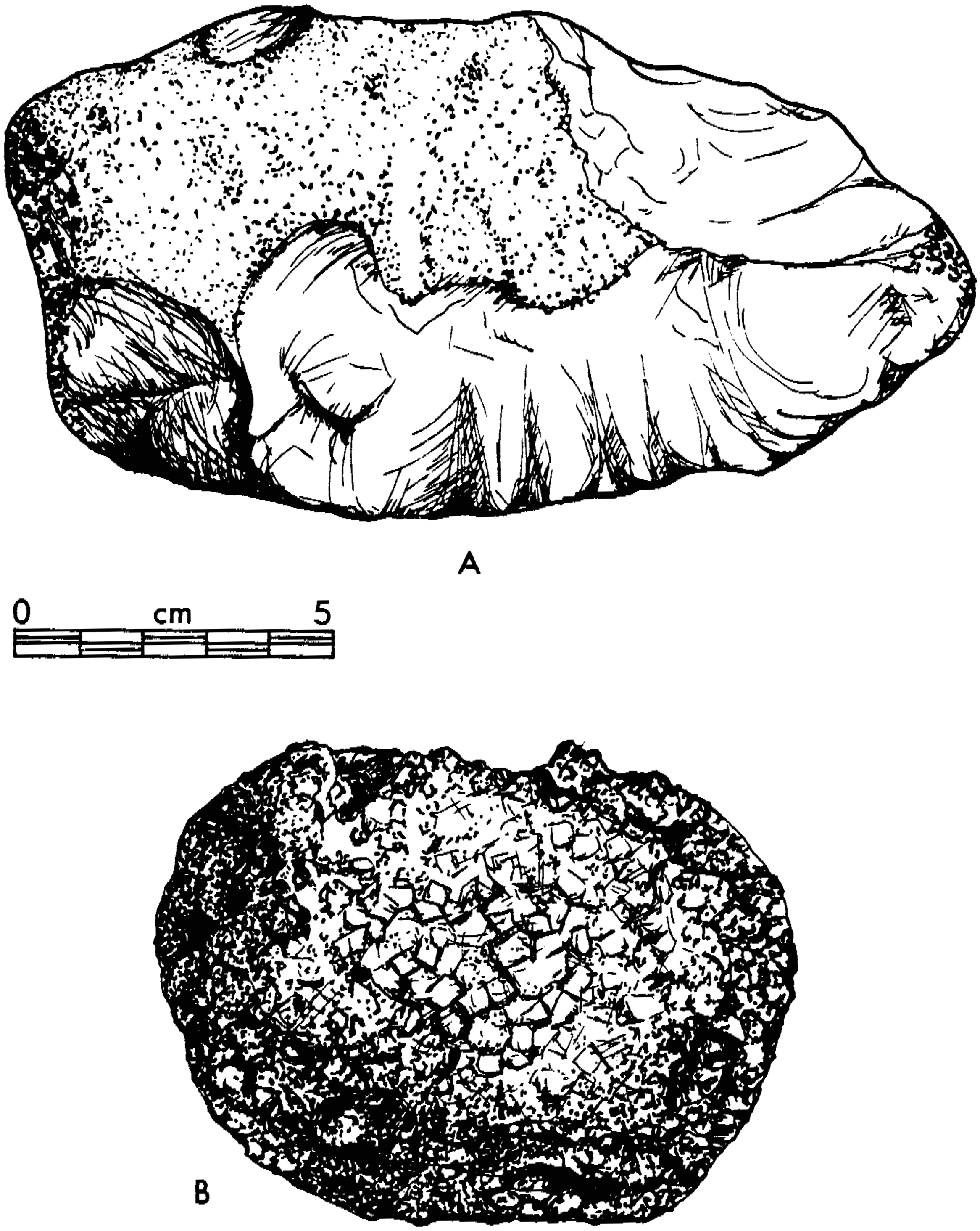

Figure 21. Large tool and grinding implement. A, Core tool/chopper - hammerstone - heavy flaking and medium battering ((A201-772); B, mano - shaped, discoidal biface (A201-826).

Table 12. Size Range of Scrapers

	Minimum	Maximum	Mean
Length	15.7 mm	75.0 mm	49.0 mm
Width	13.2 mm	70.8 mm	42.7 mm
Thickness	10.4 mm	27.0 mm	16.6 mm
Weight	3.2 g	94.1 g	41.0 g

B. Retouched Flake (N=12).

A retouched flake is a flake or blade that has been marginally chipped along one or more edges. Nine specimens are chert and three are obsidian. Eight are decortication flakes, two are second stage thinning flakes, and one is a second stage shatter. The reduction stage of one flake could not be determined. Figure 22-D is an illustration of a retouched decortication flake. Table 13 lists the range of discrete measurements.

Table 13. Size Range of Retouched Flakes

	Miminum	Maximum	Mean
Length	18.9 mm	47.3 mm	27.5 mm
Width	12.3 mm	30.3 mm	20.0 mm
Thickness	2.4 mm	14.8 mm	8.4 mm
Weight	.5 g	13.5 g	5.5 g

II. Bifacial (N=65).

A. Drill (N=2).

A drill is defined as a chipped artifact that exhibits a long, narrow bit, roughly parallel sides, and is thin and diamond shaped in cross-section. Both specimens are made from chert; neither is complete. One is a mid-section and the other is a base. The base and the only complete specimen in the entire collection, found in an excavated unit and not included in the range of measurements below, are illustrated as Figures 22-F and G. Table 14 illustrates the size range of the drills.

Table 14. Size Range of Drills

	Length	Width	Thickness	Weight
Specimen #A201-554	10.3 mm	6.2 mm	2.3 mm	.1 g
Specimen #A201-1735	15.9 mm	22.1 mm	4.4 mm	1.4 g

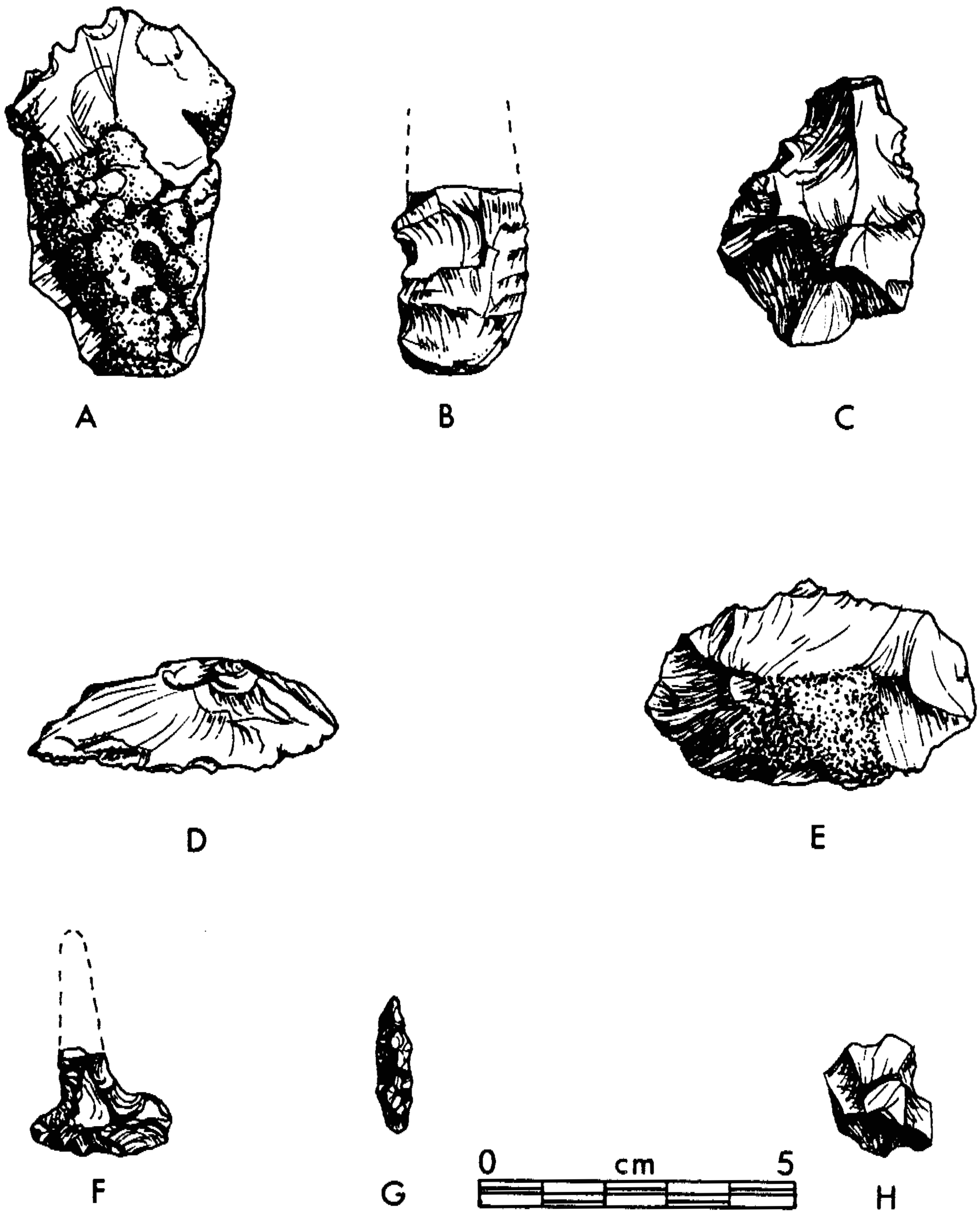

Figure 22. Small tools. A, possible cutting tool (A201-413); B, knife base (A201-1049); C, scraper (A201-1037); D, retouched flake (A201-793); E, complete preform (A201-855); F, drill base (A201-1735), G, complete drill - excavated (A201-1736); H, exhausted core (A201-1975).

B. Knife Base (N=2).

A knife is defined as a relatively large tool which is triangular in plan and lenticular in cross-section as a result of pressure-flaking. A knife usually exhibits a straight edge and pressure-flaked scars. Both specimens in the collection are knife bases made from chert. Neither exhibits cortex. Figure 22-B is an illustration of one of the knife bases. The range of discrete measurements is listed in Table 15.

Table 15. Size Range of Knife Bases

	Length	Width	Thickness	Weight
Specimen #A201-704	36.0 mm	18.6 mm	6.2 mm	3.8 g
Specimen #A201-1049	29.2 mm	20.7 mm	5.2 mm	4.2 g

C. Projectile Point (N=14).

A projectile point is a thin, light tool, generally triangular in plan and lenticular in cross-section that exhibits scars produced from pressure-flaking. Few projectile points or fragments were recovered in the 25 percent surface sample. Due to the chronological information that projectile points can provide, all complete and broken projectile points from the entire surface and subsurface collection are analyzed in this report. Table 15 provides the discrete measurements and other information for these artifacts.

1. Cottonwood Series (N=2).

Two varieties of the Cottonwood Series, the Cottonwood Triangular and the Cottonwood Leaf-shape, were recognized by Lanning (1963) in the description of projectile points from the Rose Spring Site. Along with the Desert Side-Notch point and brownware ceramics, Hester (1973:127) places the Cottonwood Series into the late Prehistoric period. The beginning of the period is ca. A.D. 1000 or later. It continues into the Historic period. The cultural materials are attributed to the Paiute and the Shoshone.

One each of the two varieties of the Cottonwood Series is present in the collection from Bovine Bluff. The points were recovered in adjacent 2 X 2 meter collection units and may represent the evidence of a single Paiute visit. Both specimens are made of chert. The Cottonwood Triangular specimen (Figure 23-H) is complete and exhibits a lenticular cross-section. Its shape is almost that of an equilateral triangle and it is difficult to

Table 16. Bovine Bluff Projectile Points

Catalog#	Provenience		Type	Material	Condition	L. (Measurements, millimeters)	W. (Measurements, millimeters)	Th. (Measurements, millimeters)	Wt. (grams)	DSA (Angles, degrees)	PSA (Angles, degrees)	NO (Angles, degrees)
1561	209N/397W	-7cm	RS	Chert	Complete	24.2	16.2	3.3	1.1	160	70	60
705	214N/386W	S1	RS	Chert	Base only Shoulders/stem broken	15.3+	12.4	3.1	1.1	-	-	-
304	204N/390W	S2	RS	Obsidian	Base only	11.5+	15.8	2.8	.5	145	105	60
1568	216N/400W	S2	RS	Chert	Base only	12.7+	15.4	3.1	.7	145	40	60
1928	198N/384W	S2	RS	Chert	Tip broken	21.4+	11.6	3.0	.9	155	45	25
473	212N/392W	S2	RS	Chert	Tip broken	17.7+	17.9	3.4	1.1	155	60	80
1004	238N/406W	S1	RS	Obsidian	Tip, side, shoulder broken	18.0+	9.6+	3.2	.6	-	-	-
232	220N/402W	S1	CT	Chert	Complete	18.2	17.3	4.4	1.5	-	-	-
236	220N/404W	S2	CL	Chert	Tip broken	16.7+	11.7	3.6	.8	-	-	-
1750	214N/386W	-10cm	BM?	Chert	Tip broken	31.6+	22.6	5.0	4.2	-	-	-
1128	218N/354W	S1	SN?	Chert	Tip broken	22.2+	12.9	3.6	1.1	-	-	-
842	218N/378W	S1	FP	Chert	Complete	17.1	13.7	3.4	.8	-	-	-
1969	214N/394W	S1	FP	Chert	Complete	17.6	9.7	2.6	.3	-	-	-
1970	226N/390W	S1	FP	Chert	Tip broken	18.2+	12.6	3.2	.5	-	-	-

KEY: Provenience - S1=Surface/25% collection, S2=Surface/non-25%. Type - RS=Rose Spring, CT=Cottonwood Triangular, CL=Cottonwood Leaf-Shape, BM?=Possible Basketmaker, SN?=Double side-notch, FP=Flake Point. Angles - DSA=Distal Shoulder Angle, PSA=Proximal Shoulder Angle, NO=Notch Opening.

determine which side is the base. The longest side is convex and is considered the base. The Cottonwood Leaf-shape specimen (Figure 23-I) has a broken tip and exhibits a plano-convex cross-section and a concave base.

2. Rose Spring Series (N=7).

Lanning (1963:252) recognized a series of "small, stemmed projectile points....the blades range from convex-sided to concave-sided, bases are straight or convex...edge serration is common." The Rose Spring points are primarily contrasted with the Eastgate Series by the difference in the shoulders. The Eastgate Expanding-Stem exhibits "long, broad barbs set off by two basal notches (pg. 253)." Hester (1973:127-128) places the two series into "...the Rose Spring - Eastgate Complex, representing the epoch in which the bow and arrow...were introduced, roughly A.D. 500 - 1000..." Thomas (1981:19-20) considered the Rose Spring and Eastgate projectile points in the collection from Monitor Valley, Nevada to be of one type, the Rosegate, since "the types obviously grade into one another..." and agree chronologically.

Although the Rose Spring and Eastgate points may grade into one another in the Monitor Valley collection, seven specimens from the collection of projectile points at Bovine Bluff exhibit shoulders and stems similar to those of the Rose Spring variety. The Rose Spring projectile points at Bovine Bluff are illustrated in Figure 23-A through G. All exhibit lenticular cross-sections. Six are made from chert and one from obsidian. One specimen is complete, two have broken tips, one has a broken tip, side and shoulder, and three specimens are only bases. Four artifacts have serrated sides. Bases range from straight (4), to convex (2), to convex - pointed (1). Six specimens exhibit barbed shoulders and one cannot be determined.

3. Miscellaneous Points (N=2).

Two projectile points do not fit into traditional type schemes for this area. One specimen is probably a Basketmaker-type point (Figure 23-J). It is large with a wide stem and squared shoulders. Along with massive quantities of flakes and sherds, the point was recovered in an excavated unit in a level from the vesicular A horizon to 10 centimeters below the surface. It is made from chert and exhibits a lenticular cross-section. The upper third section is broken.

The other point is unique in that it exhibits two side-notches on each side (Figure 23-K). It is made from chert, exhibits a lenticular cross-section, a convex base, and serrated sides. The tip has been broken.

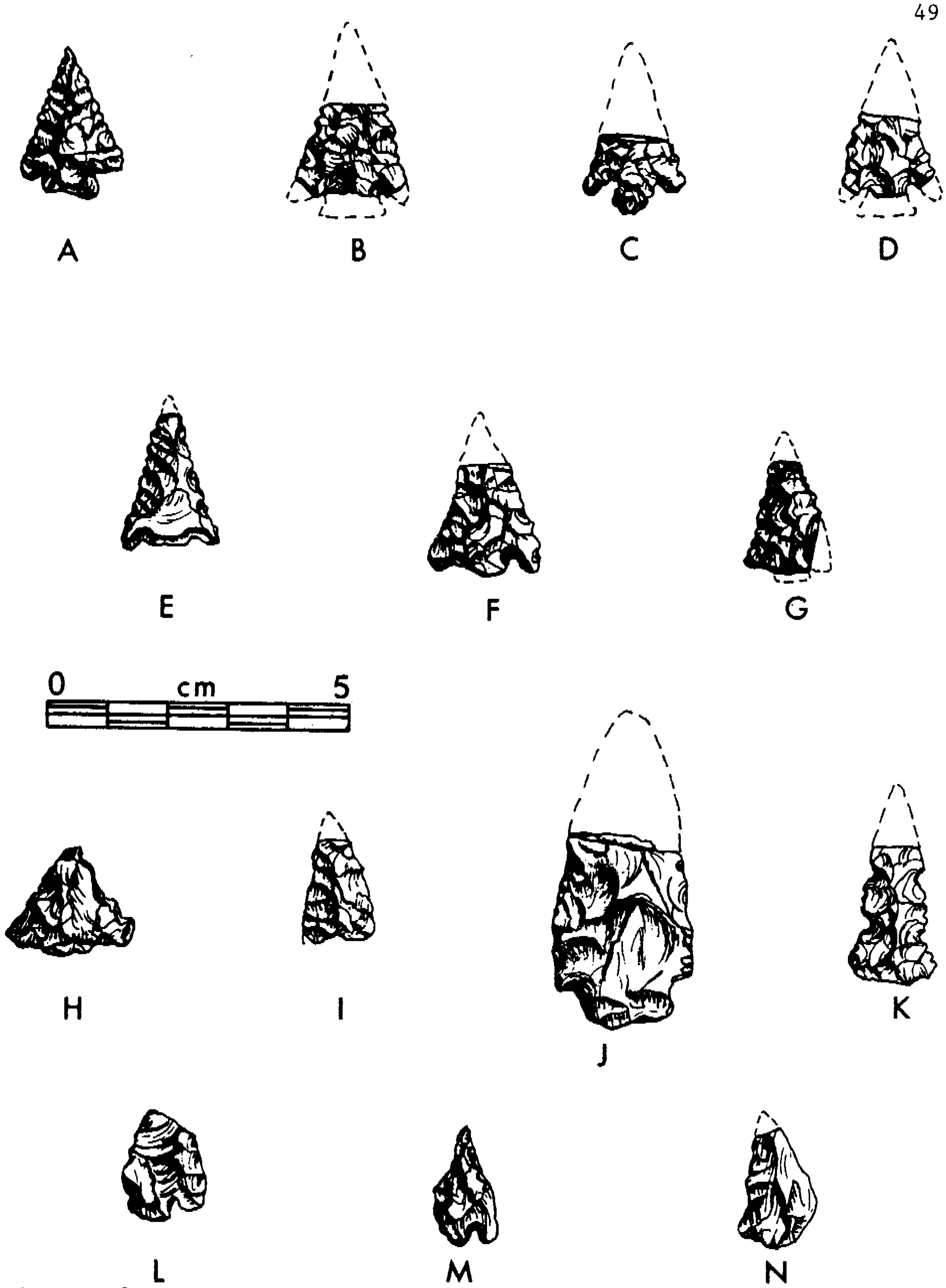

Figure 23. Projectile points. A–G, Rose Spring series (A201-1561, 705, 304, 1568, 1928, 473, 1004); H, Cottonwood Triangular (A201-232); I, Cottonwood Leaf-shaped (A201-236); J, undetermined - possible Basketmaker (A201-1750); K, undetermined - possible Lower Colorado variety (A201-1128); L–N, flake points (A201-842, 1969, 1970).

Though the notches pose a problem in assigning the point to a particular culture, its overall size and shape resemble Lower Colorado points. Schroeder (1979:101) notes that the Hakataya "...preferred medium to long unnotched, triangular points with a concave to convex base."

4. Flake-Points (N=3).

Three small, chert specimens are flakes made into miniature projectile points (Figure 23-L through N). While most of the projectile points were collected from non-25 percent units in areas that had been 100 percent collected, all three of these points were recovered from the 25 percent sample units. One complete specimen exhibits evidence of post-removal pressure-flaking only on the edges of both the ventral and dorsal surfaces. Its size and curved shape indicate its origin as a biface thinning flake. It exhibits a plano-convex cross-section and a basal notch.

Rather than just exhibiting edge-retouch, the other two points are broadly flaked across the ventral and dorsal surfaces. One specimen is complete and exhibits a lenticular cross-section and a basal notch. The other specimen exhibits a plano-convex cross-section, a straight base, and a broken tip.

D. Undetermined Biface (N=47).

An undetermined biface is defined as any tool that has been bifacially reduced but does not conform to the definitions listed above. It includes preforms and completed biface fragments that cannot be identified as to category.

1. Small Fragments of Completed Tools (N=2).

This category includes small fragments of completed, pressure-flaked tools, such as knives or projectile points. The artifacts could not be identified as to the particular type of tool. Both specimens are made from chert, exhibit lenticular cross-sections, and an absence of cortex. One is the edge of a tool, the other a base. Table 17 lists the range of discrete measurements.

Table 17. Size Range of Small Fragments of Completed Tools.

	Length	Width	Thickness	Weight
Specimen #A201-1134	29.0 mm	16.7 mm	7.4 mm	3.6 g
Specimen #A201-1967	23.3 mm	9.5 mm	4.0 mm	.6 g

2. Possible Cutting Tools (N=4).

Four artifacts classified as undetermined chert bifaces are bifacially worked on one edge, and exhibit a sharp, cutting edge. Any amount of utilization could not be determined. Outlines range from ovoid (1), to elongate (2), to irregular (1). Cross-sections range from lenticular (1), to bi-convex (3). Percentages of remaining cortex range from 20 to 80 with a mean of 55 percent. A possible cutting tool is illustrated in Figure 22-A. Table 18 illustrates the range of discrete measurements of these artifacts.

Table 18. Size Range of Possible Cutting Tools.

	Length	Width	Thickness	Weight
Specimen #A201-1984	35.3 mm	29.4 mm	11.5 mm	10.1 g
Specimen #A201-1086	49.8 mm	21.3 mm	13.8 mm	21.6 g
Specimen #A210-413	56.0 mm	37.6 mm	17.7 mm	41.9 g
Specimen #A201-743	32.1 mm	28.8 mm	13.7 mm	13.5 g

3. Biface Preforms - Complete (N=8).

Preforms are the core results of stages of manufacture of a bifacial tool. They exhibit lenticular or bi-convex cross-sections and some parallel flaking depending on the stage of manufacture. Six of the preforms in this category are made from chert and two from quartz. Five exhibit lenticular cross-sections while three exhibit bi-convex cross-sections. The percentages of remaining cortex range from 0 to 25 with a mean of 11 percent. A preform is illustrated in Figure 22-E. Table 19 shows the range of discrete measurements.

Table 19. Size Range of Complete Biface Preforms.

	Minimum	Maximum	Mean
Length	26.0 mm	68.0 mm	43.9 mm
Width	17.8 mm	48.8 mm	30.7 mm
Thickness	5.9 mm	24.3 mm	14.3 mm
Weight	3.1 g	74.3 g	25.1 g

4. Tips, Bases, and Mid-sections of Preforms (N=8).

All eight chert specimens exhibit lenticular cross-sections and an absence of cortex. Three are tips, three are mid-sections, and two are either tips or bases. Table 20 lists the range of discrete measurements.

Table 20. Size Range of Tips, Bases, and Mid-sections of Preforms

	Minimum	Maximum	Mean
Length	9.4 mm	29.0 mm	16.7 mm
Width	7.0 mm	19.1 mm	18.8 mm
Thickness	1.9 mm	6.1 mm	4.7 mm
Weight	.3 g	3.4 g	1.8 g

5. Large Fragments of Preforms (N=14).

All 14 artifacts are made from chert. Three exhibit lenticular and 11 exhibit bi-convex cross-sections. Percentages of remaining cortex range from 0 to 30 with a mean of 4 percent. Table 21 illustrates the range of discrete measurements of the artifacts.

Table 21. Size Range of Large Preform Fragments

	Minimum	Maximum	Mean
Length	22.7 mm	50.2 mm	32.6 mm
Width	11.5 mm	31.4 mm	20.1 mm
Thickness	7.0 mm	13.7 mm	10.8 mm
Weight	2.9 g	20.8 g	8.0 g

6. Minimally-Flaked Preforms (N=11).

This category includes irregularly-shaped, minimally bifacially-flaked specimens with the presumed intent to be made into tools. All 11 artifacts are made from chert. Three exhibit lenticular and eight exhibit bi-convex cross-sections. Outlines range from ovoid (2), to elongate (2), to irregular (4). The percentages of cortex remaining range from 0 to 70 with a mean of 19 percent. Table 22 lists the size range of the specimens.

Table 22. Size Range of Minimally-Flaked Preforms

	Minimum	Maximum	Mean
Length	27.1 mm	52.0 mm	35.1 mm
Width	15.3 mm	33.9 mm	27.3 mm
Thickness	10.2 mm	24.5 mm	15.4 mm
Weight	4.1 g	43.1 g	16.9 g

Cores (N=11)

Crabtree (1972:54) partially defines a core as a "piece of isotropic material bearing negative scars, or scar." Since a continuum exists from very small, obviously exhausted cores (under 4 grams), to very large minimally reduced cores (greater than 86 grams), no further subcatagorization is made. The requirement for entry into this category is the presence of negative flake scars and the apparent lack of shaping evidenced by the lack of lenticular or plano-convex cross-sections. All 11 of the specimens are made from chert. The percentages of remaining cortex range from 0 to 65 with a mean of 20 percent. An exhausted core is illustrated in Figure 22-H. Table 23 illustrates the size range of discrete measurements of the cores.

Table 23. Size Range of Cores

	Minimum	Maximum	Mean
Length	12.2 mm	54.2 mm	33.2 mm
Width	12.0 mm	50.7 mm	27.7 mm
Thickness	11.1 mm	28.4 mm	18.0 mm
Weight	3.7 g	86.4 g	24.1 g

Discussion

The composition of the lithic assemblage at Bovine Bluff indicates a strong dependence on activities associated with hunting. In the large tool catagory there is a complete continuum from core tool/choppers to hammerstones. Though a few tools have both been battered and flaked, it does not appear that the large tool technology was one of consistent re-use. The ready availability of limestone for core tool/choppers and quartz for hammerstones would make possible the option of discard once the tool had been sufficiently utilized. It is not known at this time whether or not such a pattern did exist.

It is interesting to note the comparison of the estimated amount of use in the large tool category. While the larger percentages of core tool/choppers are in the light to medium flaking categories, the larger percentages of hammerstones are in the light and heavy battering categories. It is possible that the differences are related to both function and the availability of quality tool-materials. For example, good hand-sized limestone rounded cobbles may be more numerous than similar sized quartz cobbles. Also, the natural morphology of a hammerstone may have been considered to be more important than that of the core tool/chopper. Perhaps a good hammerstone was hard to find and when one was found, it was saved. The categorization of the large tools by this method is experimental and larger sample sizes are needed in order to explore these apparent differences.

Small tools also seem to be well-represented in the collection. Preforms, fragments of preforms, and undetermined bifaces number more than 40 specimens. There are 11 cores ranging in size from 3.7 to 86.4 grams. The distribution of debitage reduction classes correlates well with the large quantities of small tools. It is expected that a sedentary site should have a higher frequency of thinning and interior flakes implying that more of the final reduction phases might have taken place during leisure hours near the site. Almost 60 percent of the total quantity of flakes at Bovine Bluff are thinning and interior flakes.

GRINDING IMPLEMENTS

Manos and metates are stone artifacts usually made from sandstone, basalt, or quartz. They are used for the grinding of seeds, agricultural products, or even meat. A mano is a grinding tool that is held in the hand and used to rub or grind on the surface of the metate. Definitions of mano and metate categories are derived from Warren et. al. (1978:52-55).

A visual determination of the amount of use-wear on each specimen was made. Light use is defined as evidence of grinding without having significantly reduced the roughness of the cortex. Medium use is defined as evidence of grinding that had, in some areas, worn the surface smooth. Heavy use is defined as evidence of grinding that had worn more than 50 percent of the surface smooth.

Manos (N=6)

I. Unshaped Uniface Manos (N=2).

These manos exhibit unmodified outlines and have been utilized on only one surface. One specimen is made from a quartz cobble and one from a vesicular basalt cobble. Both exhibit medium use-wear; neither are complete. Table 24 lists the range of discrete measurements of these artfifacts.

Table 24. Size Range of Unshaped Uniface Manos

	Length	Width	Thickness	Weight
Specimen #A201-723	122.8 mm	119.4 mm	52.4 mm	1222.8 g
Specimen #A201-441	180.0 mm	101.3 mm	71.0 mm	1451.0 g

II. Shaped Manos (N=4).

These are bifacially used specimens that exhibit modified outlines by grinding and battering.

A. Elongate (N=3).

All three elongate-shaped specimens are made from quartz. One exhibits heavy use-wear on both sides while the other two exhibit medium use-wear on one side and heavy use-wear on the other. None are complete; less than half of the objects remain. Table 25 lists the discrete measurements of these artifacts.

Table 25. Size Range of Shaped Elongate Manos

	Length	Width	Thickness	Weight
Specimen #A201-816	80.5 mm	64.6 mm	38.0 mm	256.4 g
Specimen #A201-701	85.4 mm	54.6 mm	41.8 mm	305.4 g
Specimen #A201-143	144.0 mm	78.2 mm	54.2 mm	661.5 g

B. Discoidal (N=1).

This disc-shaped specimen is made from basalt and exhibits medium use-wear on one side and heavy use-wear on the other side. Approximately one-third of the object is remaining. Table 26 lists the range of measurements. The artifact is illustrated in Figure 20-B.

Table 26. Size of Shaped Discoidal Mano

	Length	Width	Thickness	Weight
Specimen #A201-826	98.1 mm	72.4 mm	51.6 mm	509.2 g

III. Mano or Metate Fragments (N=1).

Only the edge of an undetermined grinding implement remains. It is made from quartz and exhibits heavy use-wear. Its weight is 88.8 grams.

Metates (N=0)

No metates were collected in the 25 percent surface sample. One explanation for this is associated with the preferences of unathorized collectors. Lightfoot and Francis (1978) determined that unauthorized collectors prefer certain types of artifacts over others. Projectile points, bifacial tools, and painted and corrugated pottery are preferred to flakes and plain pottery. Rather than slab metates, basin or trough metates are the expected types at Bovine Bluff. Since basin or trough metates seem to best fit the aesthetic concept of a metate, it is probable that unauthorized collectors would prefer them over slab metates. Manos are thinner and constantly moved around during use. It would be expected that they would break far easier than metates. Since the fragments of unshaped and shaped manos do not best fit the aesthetic concept of manos, they would not be expected to be collected as readily.

Discussion

The lack of metates and the presence of only six fragmented manos is likely a function of the activities of unauthorized collectors. Four of the manos were shaped and bifacially used indicating that grinding activities were considered important. The small sample of grinding implements precludes further analysis.

DATING OF BOVINE BLUFF

Virgin Anasazi Chronology

Based on previous chronological classifications for the Virgin Anasazi, Shutler (1961) defined and developed the present chronology for the Puebloan occupation of southern Nevada.

Moapa phase (BMII, 300 B.C.?-A.D. 500). This is the first recognized phase of Anasazi occupation in the area. It is characterized by pithouses located on high bluffs and the absence of pottery.

Muddy River phase (BMIII, A.D. 500-700). Clusters of one to four pithouses on high mesas rimming the valleys and low knolls characterize this phase. The aborigines began to farm the valley floor during this time. Small, stemmed notched points and plain pottery were made. Bins and cists were used for storage.

Lost City phase (PI-PII, A.D. 700-1100). This phase is characterized by pit and surface houses, sometimes in a U-shaped design, built on low knolls on the course of the Muddy and Virgin Rivers. An increase in the population may be correlated with an increasing subsistence base dependent on agriculture along with the gathering of wild resources. Wide trade networks were developed and corrugated pottery was introduced.

Mesa House phase (PIII, A.D. 1100-1150). This is considered to be the last phase of occupation before abandonment of the region occurred. It is characterized by surface and pit dwellings defensively constructed on ridges at the edge of and high above the valley floor. There was an increase in corrugated over plain pottery.

Radiocarbon Dates

The processing of two radiocarbon samples from the Bovine Bluff site was funded under the auspices of a grant from the Graduate Student Association Research and Scholarship Council, University of Nevada, Las Vegas. Charcoal from Pit 4, associated with tortoise bone, yielded a date of 1000 $\pm$ 50 years B.P.: A.D. 950 (Lab # Beta-Analytic 9705). Charcoal from the clay-lined firepit in Pit 5 yielded a date of 1030 $\pm$ 80 years B.P.: A.D. 920 (Lab # Beta-Analytic 9706). Appendix 2 is a copy of the results from Beta-Analytic. These radiocarbon dates place the occupation of Bovine Bluff in the midpoint of the Lost City phase.

Chronological Ordering of the Projectile Points

Projectile points have traditionally served as chronological markers in North American archaeology. Rose Spring Series points account for 50 percent (7 of 14 specimens) of the total sample of points from Bovine

Bluff. This type is expected to occur in high frequencies at Virgin Anasazi sites and correlates well with the radiocarbon dates of A.D. 920 and 950.

The Cottonwood Triangular and Cottonwood Leaf-shaped points are generally associated with Paiute occupation after A.D. 1000. The two Cottonwood Series points, recovered from adjacent 2 x 2 meter surface collection squares, may represent evidence of a single Paiute occupation at Bovine Bluff.

The Basketmaker-type point was recovered in the screen from an excavation unit on the periphery of the disturbed architectural area. The unit yielded massive quantities of flakes and sherds to the 10 centimeters level before excavation was halted. If it is a Basketmaker point, it may indicate either that this section of the site might have had earlier stages of occupation or that earlier type points were made along with later styles.

It would not be surprising if the double side-notched point was of a lower Colorado variety. Lower Colorado buffware pottery is commonly found in the Moapa Valley. The presence of such a point could indicate either a trade item or its discard on the site by a knapper.

What is most surprising is the recovery of three points made from small flakes. Two of the specimens have basal notches. Due to their small size, it seems unlikely they were used for hunting. It is possible that they were manufactured by individuals learning to flintknap. It is also possible that they were made as toy objects by the aboriginal occupants of the site.

The spatial distribution of the points on the site is also interesting (Figure 24). A sampling bias at least partially accounts for the distribution of most of the points in the disturbed structural area. This area was 100 percent collected and was the locus of a substantially higher proportion of archaeological activity, especially during the 1983 season. The result of such intense activity was the disturbance of the gravel armor and the appearance of flakes and small artifacts after the unit had already been collected. Two points were found on the surface as a result of this activity.

Of the 14 specimens recovered, only two are from subsurface contexts. Six are from collection squares in the 25 percent sample area and six are from non-25 percent units. All three flake-points, two Rose Spring points, and the double side-notched point were from the 25 percent sampled units.

Chronological Ordering of the Ceramic Design Styles

Using Colton and Hargrave's (1937:15-16) definitions, the decorated pottery at Bovine Bluff includes a low frequency of Lino and high frequencies of Kana-a and Black Mesa design styles (Figure 6). The chronological association of Lino is late Basketmaker III; that of Kana-a and Black Mesa is Pueblo I to Pueblo II. The introduction of

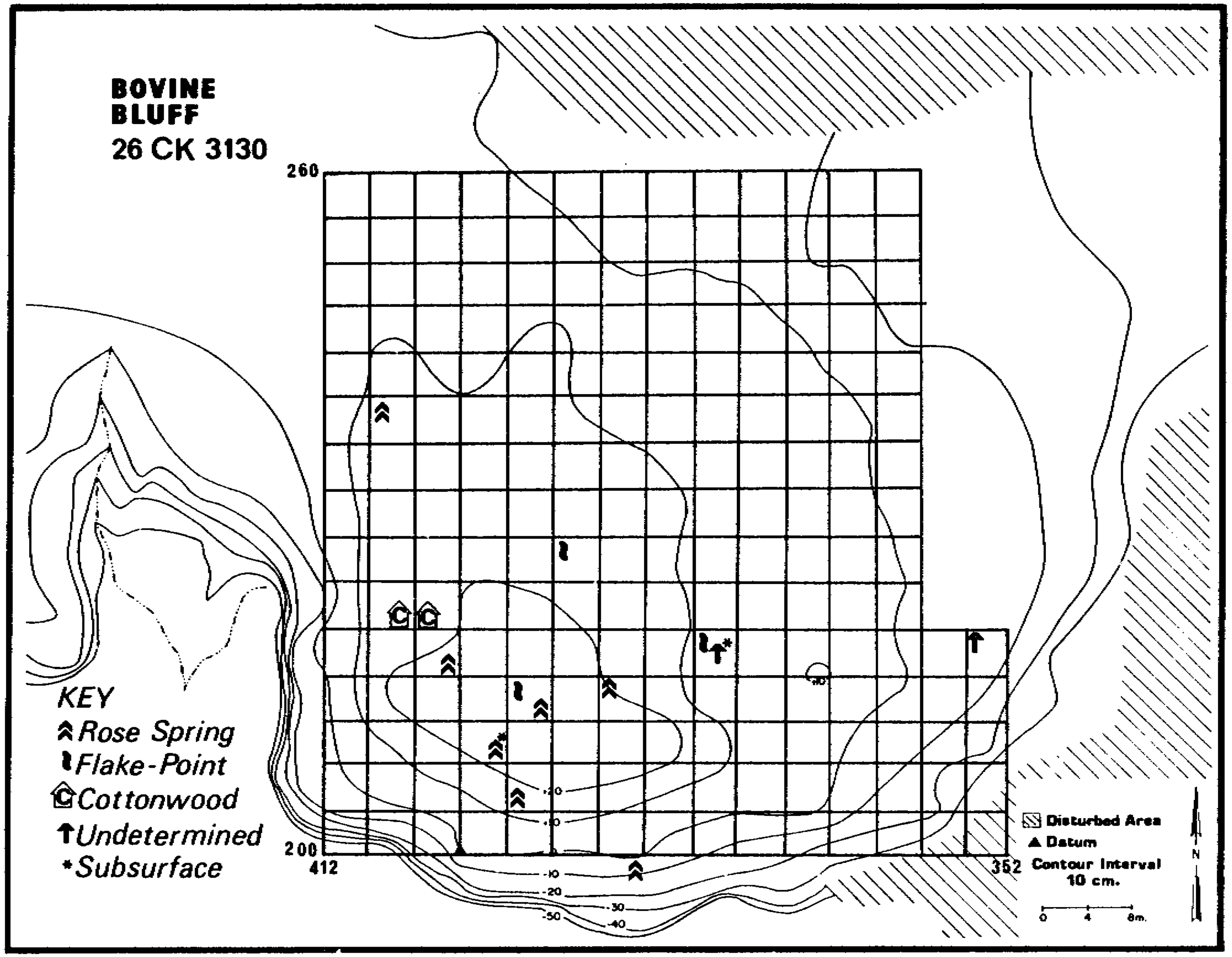

Figure 24. Spatial distribution of projectile points.

corrugated ware in the region is considered to have occurred at approximately A.D. 950. Its absence and the presence of Lino, Kana-a, and Black Mesa design styles would place the major occupation of Bovine Bluff prior to A.D. 950.

Sourcing and Hydration Analysis of Eight Obsidian Samples

Ten obsidian specimens were submitted to Dr. Richard Hughes and Dr. Thomas Origer, Sonoma State University, for sourcing and hydration analyses. Two specimens were determined to not be obsidian. Copies of the letters from Dr. Hughes and Dr. Origer presenting the results of these analyses are included in the report as Appendix 3.

Obsidian is not a plentiful material at Bovine Bluff. All of the flakes or nodule fragments are small and were saved in the screen. None were recovered in situ. Table 27 lists the results of the obsidian sourcing and hydration analyses.

Table 27. Results of Obsidian Sourcing and Hydration Analyses

Specimen No.	Provenience	Depth	C-14 Date In level?	Hydration Band Width	Source
A201-1563	210N/392W (Pit 4) N. half 1X1 m unit	30-40 cm	None	6.0 microns	A
A201-1345	210N/392W (Pit 4) S. half 1X1 m unit	45-50 cm	A.D. 950	5.6 microns	A
A201-1548	209N/397W (Pit 5) SW section of adobe-walled room.	Surface to 7-8 cm - top of wall.	None, but Firepit in center: A.D. 920.	7.7 microns	A
A201-1424	203N/396W	Fill from old backdirt	None	4.9 microns	B
A201-1747	214N/386W	Vesicular A to 10 cm	None	6.4 microns	A
A201-1586	232N/374W	Surface	None	Diffuse Hydration	A
A201-1892	243N/371W	Surface to 1 cm	None	6.6 microns	A
A201-1875	242N/371W	1 to 5 cm	None	Diffuse Hydration	A

KEY: A=One Unknown Source. B=Kane Springs Source.

Though not yielding a specific quarry location for most of the samples, the sourcing analysis did prove interesting. One of the eight obsidian samples was identified as deriving from Kane Springs, an obsidian source north of Bovine Bluff near Meadow Valley Wash. The remaining seven specimens were determined as deriving from a same but unknown source.

Due to the lack of obsidian hydration data for this region, the band width measurements at this time can only be used for relative dating purposes. One specimen at Bovine Bluff may be associated with a radiocarbon date. Excavation of Pit 4 indicated that one pit-structure may have been dug into the fill of a previous pit-structure. The fill of the most recent pit yielded specimen A201-1563 from the 30 to 40 centimeter level. The hydration width of the flake is 6.0 microns. Excavation in the fill below this possible pit-structure, at a depth of 40 to 50 centimeters, yielded a substantial amount of charcoal which produced a C-14 date of A.D. 950, one tortoise bone fragment, and obsidian specimen A201-1345. The hydration band width is 5.6 microns. The charcoal was removed in situ but the flake was recovered in the screen. Though it can not be stated with certainty, the flake may be associated with the A.D. 950 date. What is perplexing is that the band of 6.0 microns on the flake from the most recent fill is wider than the flake from the earlier fill.

An obsidian flake (A201-1548) was recovered in the screen in the fill excavated from the surface to the top of the southwest section of adobe wall in Pit 5 at eight centimeters. There are no indications that the flake was associated with the actual occupation of the adobe-walled room. Instead, the flake was probably part of the deposit that accumulated above the melted adobe wall long after abandonment of the room. What is puzzling about this specimen is its width of 7.7 microns, the widest band measured on all the samples. Presumably, a flake from this fill should not be substantially older than others retrieved on the site.

The results of the hydration analysis on two specimens from the aceramic flake area were awaited with anticipation. One flake (A201-1892) was recovered in the screened fill from the removal of the gravel armor level. This yielded a hydration width of 6.6 microns. With the exception of specimen A201-1548, this is the widest band. However, this difference in width may not imply a substantially greater age for the knapping of the flake. The width of the band of the other flake from this area (A201-1875) was considered to be too diffuse to determine.

The hydration band measurements are perplexing. One possible explanation for the variable thicknesses may be related to material curation and reuse. Until hydration rates of both the Kane Springs source and the unknown obsidian source can be positively associated with absolute dates, the results are inconclusive. They must primarily serve as data for future comparison.

Summary

The radiocarbon dates of A.D. 920 and 950 correlate nicely with the high frequency of Rose Spring projectile points at the site. In addition, the high incidence of Kana-a and Black Mesa design styles on the decorated ceramics and the absence of corrugated ware fit well with an early Pueblo II occupation. If the date of A.D. 950 is used with an expectation of the immediate introduction of corrugated ware, then a slight discrepancy exists. The problem can be at least temporarily solved by using the plus or minus range of years with the radiocarbon dates and the knowledge that the date for the introduction of corrugated pottery is not rigid. It is probable that the Virgin Anasazi occupation of Bovine Bluff ranged from approximately A.D. 900 to 950.

CONCLUSIONS

The Puebloan occupation of Bovine Bluff may have been at a critical point in the development of the Virgin Anasazi. While a liberal use of lithic tool-materials suggests a dependence on hunting activities, a large quantity of pottery and a high frequency of jar forms indicate a dependence on agriculture. An early Pueblo II occupation span correlates well with the concept of a hunting and gathering culture in the process of shifting towards a subsistence base dependent on agriculture. While the archaeology of any prehistoric site is important, the position in the chronological development of the Virgin Anasazi makes the data recovery of Bovine Bluff especially significant. Three phases of investigation have been completed: 1) the recording and mapping of the site, 2) a systematic surface collection, and 3) preliminary excavation.

Rafferty (1983:18-19) compiled a series of research questions germane to understanding the lifeway of the Virgin Anasazi. The five research topics are subsistence, social organization, trade, settlement patterns, and abandonment. Preliminary analysis of the artifacts and data recovered from Bovine Bluff indicates that the further investigation of this site can make contributions towards answering questions from three of these research topics.

First, the recovery of information concerning prehistoric subsistence is of prime importance. Due to destructive patterns of intensive pothunting, current methods of field archaeology must concentrate on the recovery of microfloral and microfaunal remains. The era of easy identification of structural remains containing jars of corn and beans dating to the last millenium is gone. In an open, unburied site like Bovine Bluff, the chance of finding burned seeds and other dietary remnants in good context are best among the debris of collapsed and melted structures. Information regarding the diet of these relatively early Virgin Anasazi agriculturalists would be one of the best contributions that the archaeology of Bovine Bluff could make.

Second, data on architectural construction and size of rooms would supply valuable information concerning the changing nature of social organization during the Lost City phase. Anasazi sites excavated in other areas of the Southwest already provide comparative information on a broad scale concerning architecture and demography. Based on demographic statistics gathered from the Western Anasazi region, a description of an average Western Anasazi site has been developed by Plog (1979:112). "Prior to about 1100, the average site had 2.9 rooms, being a farmstead occupied by a single large nuclear family or a small extended family." The delineation of individual structures at Bovine Bluff would provide comparative data that could be used in conjunction with plans from other Lost City phase Virgin Anasazi sites. Although it is probable that the remains of more than three structures will be identified at Bovine Bluff, it is likely that only a few rooms were used during any one time.

Regional Implications

Analysis of the Bovine Bluff material points to several areas of concern for future archaeological work in the Moapa Valley. First, a systematic surface collection should be considered a priority, especially on sites that may be adversely impacted. Areas of concentrated cultural activity can be identified and the collections will provide a valuable addition to the comparative data base for this region. Second, the functional associations of temper types through time need further exploration. Third, information on architecture and diet is necessary to reconstruct the development of sedentism and agriculture in the Moapa Valley. Fourth, additional research on other sites in the upper valley is necessary. Were sites in the upper valley perhaps earlier in the development of agriculture than those in the lower Moapa Valley?

The continuation of archaeological investigation at Bovine Bluff is imperitive due to its location in the upper valley and its chronological position in the agricultural development of the Virgin Anasazi. Also, the efficiency of retrieving data from undisturbed, less visible areas on a looted archaeological site would continue to be tested. The characteristics and the potential of the site to yield data pertaining to the research topics discussed above lends to the significance of Bovine Bluff. The site is significant not only with respect to the archaeology of the Virgin Anasazi, but to the larger range of prehistory of southern Nevada.

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APPENDIX 1

AN ANALYSIS OF THIN SECTIONS OF 16 POTSHERDS FROM BOVINE BLUFF (26 CK 3130)

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August 12 1985

Report No. 1
Ceramic Analytic Laboratory
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PURPPOSE OF THE ANALYSIS

This analysis of thin sections of Bovine Bluff pottery is a pilot project in the development of quantified, comparable descriptions of lowland Virgin Anasazi wares. While thin section analysis has a number of advantages over ceramic analysis done microscopically on fresh breaks with reflected light, its costs limit the number of sherds that can be sectioned and analysed, so thin section analysis of selected sherds serves largely to complement and confirm ceramic classification. Its chief values in ceramic description are in the accurate identification of mineral inclusions, the characterization of sizes and shapes of inclusions, the insight provided in distinguishing additive inclusions from those inherent in the clay, and in quantifying temper-to-paste ratios.

When classed according to temper in reflected light, three varieties of pottery are apparent at Bovine Bluff: calcium carbonate tempered, olivine tempered, and sand tempered. It is of considerable interest in coming to understand the development of Anasazi society in the lower Moapa Valley to learn whether there were really three distinct wares used at the site, and whether all of them were locally produced. The descriptive analysis is guided by these concerns. Are distinct pastes associated with the different tempers? Are the tempers locally available materials?

Of the three tempers, sand and calcium carbonate are locally available, and it has been generally assumed that pottery tempered with these materials were produced in the Moapa Valley. Olivine-tempered pottery has always been a problem, for no local sources of olivine are known. It is generally thought that the pottery, or at least the temper, originated in the Mt. Trumbull area on the north rim of the Grand Canyon, with important implications for the nature and direction of prehistoric interaction (Thompson 1978:7).

Thin section analysis is only one approach to determining the production provenience of ceramics, and alone, does not provide definitive answers. Characterization of the chemistry of the clays is almost essential, and is usually done by X-ray fluorescence, electron microprobe, or neutron activation (Lemoine, Walker and Picon 1982; Harbottle 1982). Geochemistry of tempering materials, ascertained by the same kinds of equipment, are also important in assigning pottery to provenience groups. Nevertheless, thin section analysis is an essential step in framing provenience studies, for it permits narrowing of alternatives and understanding of sherd composition in such a way that more expensive techniques can be used selectively and economically.

METHODS

Sixteen body sherds were selected for thin section analysis in the course of classifying the pottery under reflected light microscopy. They were judged to represent the range of variation apparent in the tempering material.

Five of the eight olivine-tempered sherds show the range of apparent colors of olivine in reflected light. The grains range from very pale through bright to dark greens, and are usually accompanied by red grains that may be the mineral iddingsite. This range of color was selected to verify the identification of olivine and iddingsite, to test for the presence of pyroxenes, and to search for additional minor inclusions such as rock matrix that might provide clues as to the nature of the olivine source. The other three sherds exhibited inclusions in addition to olivine and iddingsite and were examined with special interest to see if they indicated mixing of tempers, and thus pottery production at a common location with other wares.

Five calcium carbonate-tempered sherds were sectioned, again selected for their apparent variability. One appeared to have quartz inclusions in addition to the calcium carbonate fragments; the others exhibited grains in differing conditions that might reflect differing degrees of calcinization.

Sand-tempered pottery at Bovine Bluff does not show much variation. Only three sherds, each dominated by quartz grains with little else apparently present, were sectioned.

Each sherd was sawed to provide a section through the vessel wall. One half was retained to provide a control for comparison, and the other half submitted for preparation of a thin section. In the UNLV Geoscience thin section laboratory, the sawn sherds were impregnated. The sections were prepared on a Logitech PM2 precision polishing machine, and were ground to the standard thickness of 0.03 mm used in optical minerology.

The sections were examined on an Olympus petrographic microscope model 208203 with both plane-polarized (PPL) and cross-polarized light (XPL). General observations were made at the relatively low magnification of 28x using a 7x calibrated eyepiece and a 4x objective. Greater magnification was used as necessary to inspect particular grains and selected portions of each section.

Size and shape distributions are important characteristics of inclusions. Thin sections provide an excellent basis for looking at degrees of rounding of grains. Particle size is a different matter, for the apparent size of a grain in thin section only reflects where it was cut, not its maximum diameter. As Shepard (1974:120) points out, the relative measure available in thin section is useful, however, for the measurements are comparable. In this analysis, size is indicated by measuring the 10 largest grains on each section, Their distributions are plotted on histograms for comparison between sherds of a single temper and between the varieties of temper.

I have not yet devised an efficient method for estimating the temper/paste percentages on the equipment presently available. Regrettably, that important characteristic of these coarse-tempered ceramics is not included in these descriptions.

The term temper may be used in several different senses. Magetti (1982:123) uses it to refer to all non-plastic inclusions >0.015 mm. That makes functional sense, for such inclusions may contribute to the workability of clay whether they were included naturally in the clay or added in preparation of the clay. I follow Rye (1981:31) in restricting the term temper to additives, however. As he points out, this is the more common usage in archaeology, reflecting our interest in human behavior.

Natural clays are not pure clays in either mineral or grain size composition. Usually other minerals such as quartz, feldspar or micas are present as silt-sized or larger particles. The presence and characteristics of these grains tell us something about the natural clay source. In terms of human behavior they show us that a clay with these inclusions was selected for pottery making and that processing of the clay did not remove these grains. In some circumstances, it is not possible to distinguish natural from additive inclusions (Rye 1981:31) and other terminology would be appropriate. In the Bovine Bluff ceramics, the distinction is apparent, and the small grains visible in the paste that were a part of the clay will be called natural inclusions. The relative frequency of inclusions this size is estimated by counting the number in the field of view of the microscope at 28x. That field is a circle with an area of 11.6 mm^2. Where they were particularly numerous, the estimate is based on a count of a quadrant of the field, multiplied by 4.

Paste is made up of the initially plastic components, the clay and other particles less than 0.015 mm dia. Such particles are not resolved at the 28x magnification used as the analytic standard here.

As each sherd was analyzed, the data were recorded on a ceramic analytic form. The results of those observations are summarized below.

CALCIUM CARBONATE-TEMPERED SHERDS

Sherd No.	Thin Section No.
A201-1281	A202-66
A201-1376	A202-67
A201-1344	A202-68
A201-1491	A202-69
A201-1754	A202-70

Sherds indentified as calcium carbonate tempered under reflected light proved in thin section analysis to be tempered with crushed limestone. Since reaction with cold, dilute HCl is our general check for these tempers when visual inspection leaves us uncertain, calcium carbonate is a suitable informal name for this temper. In thin section, the fragments are consistently angular. A minority of them show residual calcite twinning, and some retain their extinction in XPL. In both respects they contrast with caliche, which is also $CaCO_3$. The size and angularity of the grains indicate that the crushed limestone is a temper, not a natural inclusion. Natural fragments of limestone would be small and rounded as a result of the nature of limestone weathering in an arid environment.

Limestone is chemically $CaCO_3$ and mineralogically it is fine-grained calcite. Calcite decomposes to carbon dioxide and calcium oxide at about 800-850 degrees C. Since residual calcite structure is present in some tempering grains in each section, perhaps the calcium carbonate-tempered pottery was fired at a lower temperature, and did not reach the threshold of CaO formation, or was not held there long enough for the calcite to decompose. Rye (1976:117) points out that the thermal expansion of calcite is very close to that of low-fired clay. That characteristic makes it theoretically one of the most suitable materials for tempering cooking pots, for it contributes resistance to thermal shock, in contrast to other mineral inclusions which expand more when heated and cause stress on the vessel walls during cooking. This utility may explain the use of crushed limestone as a temper during the early part of the Moapa Valley Anasazi sequence.

In the five sherds examined it was clear that crushed limestone was the sole additive temper. No grains of other material are found in the size class above 0.15 mm dia. Figure 1 illustrates the size distributions of the 10 largest grains in the carbonate-tempered sherds.

Small inclusions in the size-class 0.015-0.15 mm are much sparser in the carbonate-tempered sherds than in the sections of other varieties of Bovine Bluff pottery. Counts ranged from two to seven per 11.6 mm^2 field of view. The small inclusions in the sections of calcium carbonate-tempered sherds are rounded to subrounded quartz grains.

The texture of the paste appears smooth at 28x magnification. Its most distinctive characteristic is the rather extra-ordinary development of voids that are apparently shrinkage cracks formed during the drying of the pots. These voids appear as wavy, elongate cracks pinching out at each end. Within the Bovine Bluff sections, only the calcium carbonate-tempered sherds show substantial development of such cracks. The voids course through the paste, on the average parallel to the vessel walls, but quite undulating in their varied orientation, apparently reflecting residual shapes of the now-fused coils that form the vessel. The cracks are frequently 1 mm or so in length and 0.07 to 0.15 mm in width. Figure 2 shows the pattern of shrinkage voids in section A202-66.

Rye (1981:113) argues that relatively high porosity contributes to thermal shock resistance. If he is right, then the calcium carbonate-tempered ware has two characteristics that should make it durable in cooking, its temper and shrinkage voids.

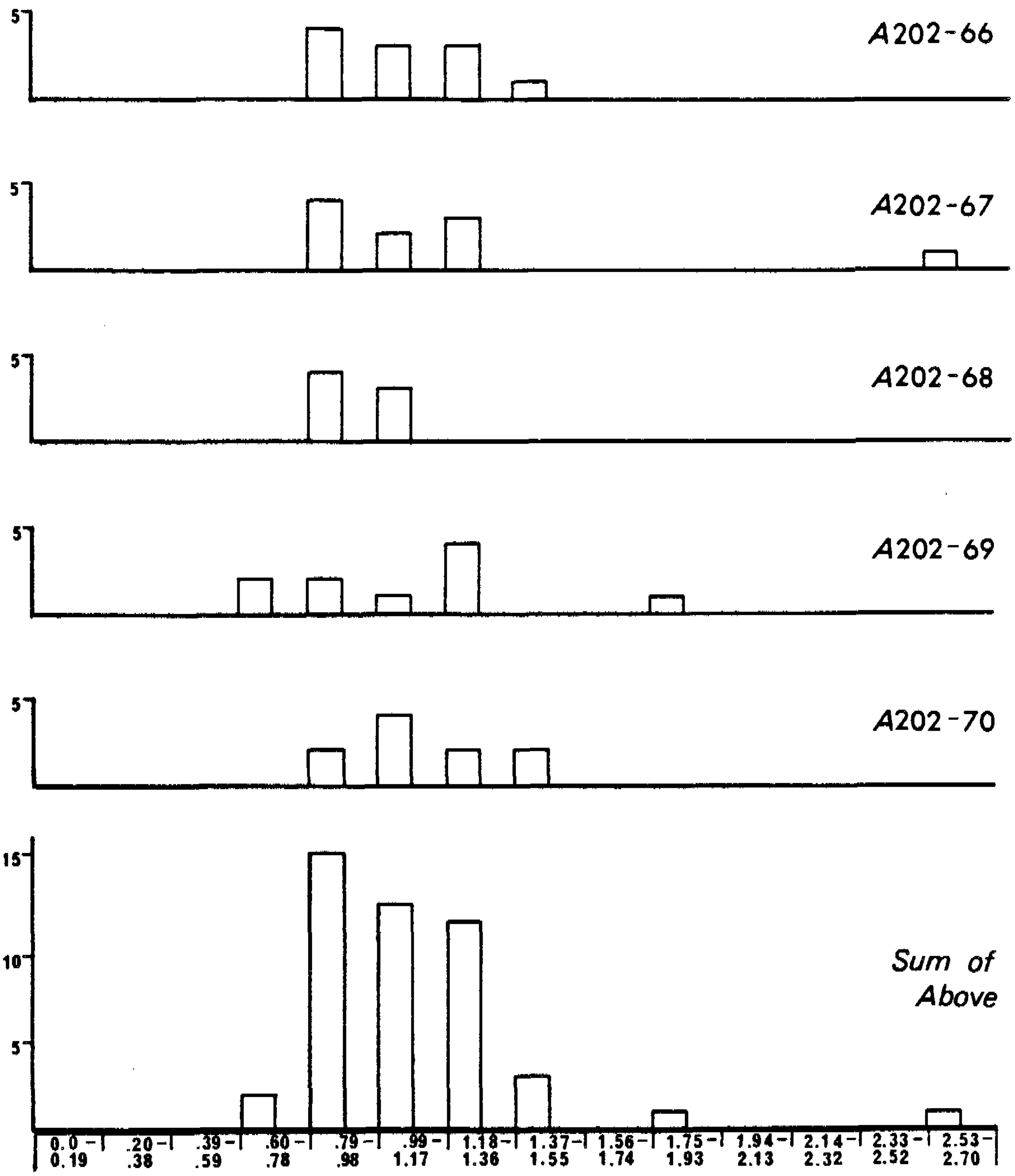

Figure 1. Size distribution of the 10 largest grains in the thin sections of carbonate-tempered sherds.

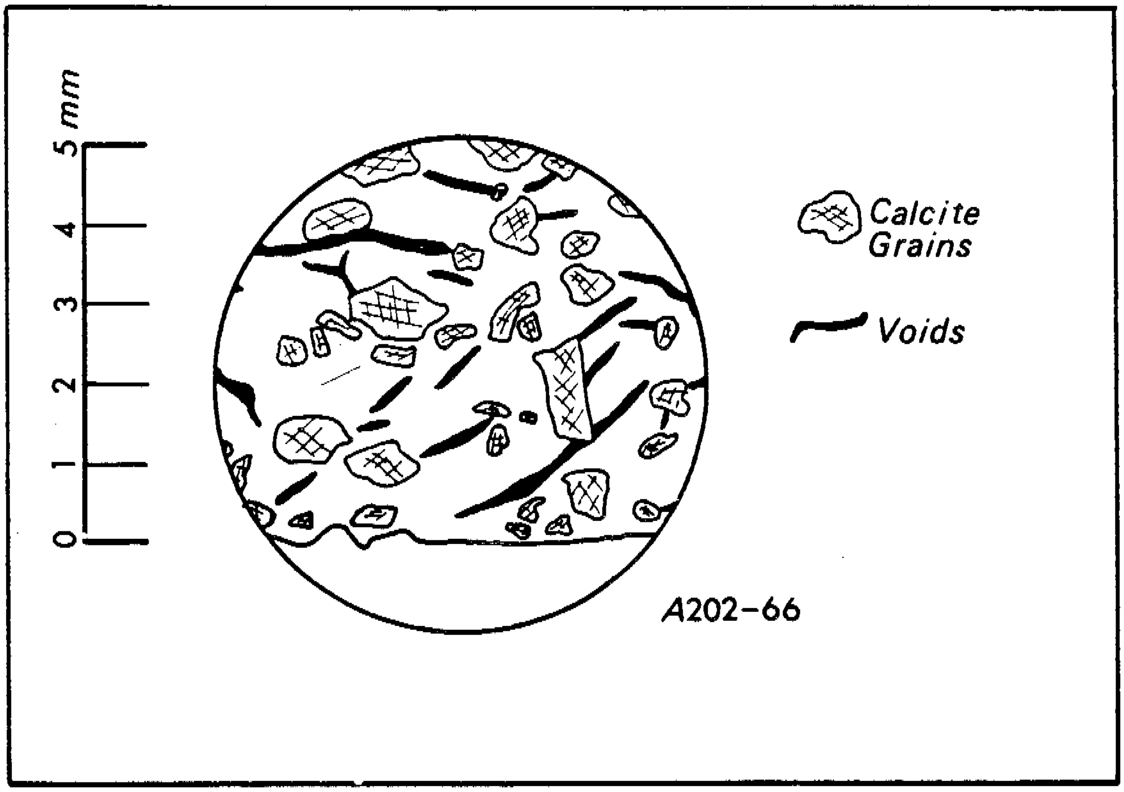

Figure 2. Graphic representation of calcite grains and voids in a thin section of a carbonate-tempered sherd.

OLIVINE-TEMPERED SHERDS

Sherd No.	Thin Section No.
A201-762	A202-58
A201-330	A202-59
A201-851	A202-60
A201-1102	A202-61
A201-860	A202-62
A201-762	A202-63
A201-868	A202-64
A201-1088	A202-65

Sherds from Bovine Bluff are initially classed as olivine tempered when fresh beaks exhibit translucent grains varying from pale through bright to dark green, sometimes accompanied by pink to bright to dark red grains thought to be iddingsite. Since the production locale of olivine-tempered pottery is of great interest, mineralogical clues of the mineral composition are important. At the same time the "olivine" temper is unsettlingly variable in reflected light, because of the variety of color present, both within some sherds and between different sherds. In addition, Felts (cited in Weide 1978:180) identified pyroxene in thin sections of Moapa Valley pottery.

A synopsis of the notes of the reflected-light microscopy of sherds selected for thin sections indicates how variable the "olivine" temper is. A201-330, -1102 and -1088 were the only ones that seemed to exhibit only olivine and iddingsite. A201-762 also had a bright green grain with prismatic cleavage, something olivine does not have, on its broken surface. A similar grain showed on the fresh break of A201-860, but here the olivine-iddingsite temper was also apparently accompanied by small but visible quartz grains. Three other sherds showed inclusions in addition to olivine and iddingsite: A201-762 also appeared to have small quartz grains; A201-851 also had small quartz and iddingsite as minor components along with dirty sand.

In thin section, the olivine grains are sharply angular, reflecting olivine's irregular cleavage. In several sherds, a grain of olivine temper proves to be made up of several olivine crystals. Both of these characteristics indicate that massive clusters of olivine crystals were crushed for temper. The size distribution of temper grains is shown on Figures 3 and 4.

Because olivine-tempered pottery is distributed from the Moapa Valley east as far as Mt. Trumbull, the Mt. Trumbull region is a likely source of the temper. In the Mt. Trumbull area masses of olivine crystals occur as zenoliths in some basalt units. For comparison, a thin section was prepared from one specimen of massive olivine, recovered by Dr. Richard Thompson, Southern Utah State College, from a Basketmaker II/III site in Grand Canyon National Monument.

In thin section, the Tuweep specimen proved to be a dunite, in that about 90% of it was, in fact, olivine. The olivine is accompanied by an orthopyroxene, identified as hypersthene by Dr. Eugene Smith, Department of Geoscience, UNLV. Visual inspection indicates that the orthopyroxene makes up close to 10% of the specimen. If it had exceeded 10% the rock would be a peridotite, harzbergite (MacKenzie, Donaldson and Guilford 1982:79-80). The Tuweep specimen also has a few grains of a mineral opaque in XPL and dark brown in PPL that is probably chromite, or chrome spinel, both of which are commonly found in dunites. The specimen is notably lacking in iddingsite grains, however.

The one specimen from the Tuweep area cannot indicate how variable the composition of zenoliths in that area may be. The co-occurrence of olivine and orthopyroxene has an important lesson: we should expect pyroxenes to accompany olivine if crushed dunite or peridotite is the temper source. The absence of iddingsite in the Tuweep specimen is perhaps more of a problem, but apparently is an expression of compositional variable at the source area. A quick inspection of thin sections of sherds of Moapa Brown from the Tuweep vicinity (also provided by Dr. Thompson) indicates the presence of iddingsite in their temper.

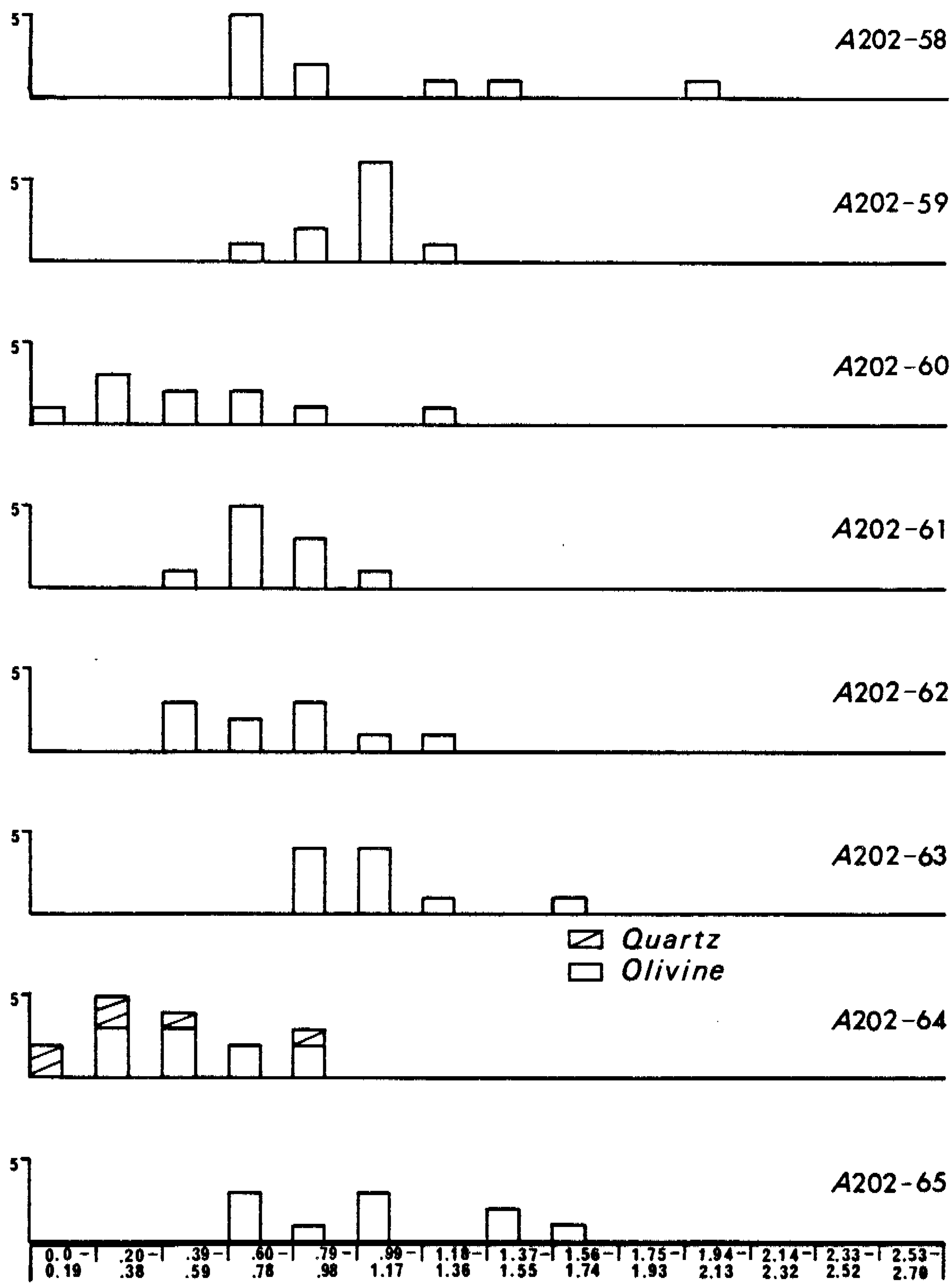

Figure 3. Size distribution of the 10 largest grains in the thin sections of olivine-tempered sherds.

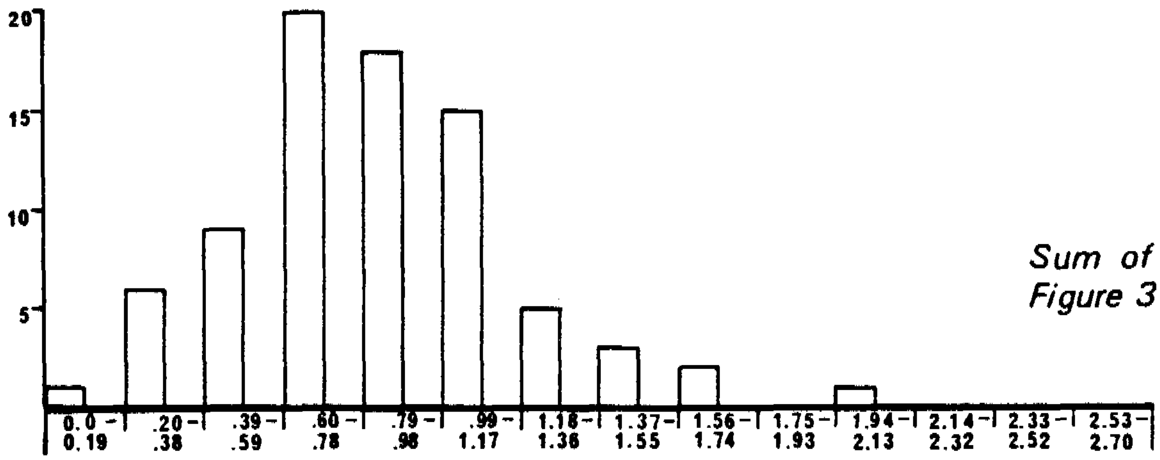

Figure 4. Total of Figure 3.

Weide (1978) conducted X-ray diffraction studies of a small sample of olivine-tempered sherds with a particular eye to testing for the presence of garnet and pyroxenes. He found garnet absent, and was unable to confirm the presence of iddingsite as an explanation of the red grains. He considered them "red olivine" but stated that iddingsite might be indistinguishable from olivine in X-ray diffraction studies. In thin section the two are readily distinguished, for iddingsite grains are distinctly stained with red-brown in PPL and have a lamellar structure (Kerr 1977:397).

Each of the ceramic thin sections contains iddingsite along with olivine, which is predominant, and orthopyroxene. The olivine-tempered sherds also consistently exhibit small dark brown to black opaque grains that are probably magnetite, chrome spinel or chromite, and are usually present in dunite and peridotite. All of these are considered to be normal constituents of "olivine" temper.

The paste of the olivine-tempered sherds appears grainier at 28x magnification than that of the calcium carbonate-tempered sherds. Shrinkage cracks are absent in 3 of the sherds and much less developed in the others, always less than 0.8 mm in length and usually only 1/2 to 1/4 of that.

The thin sections show numerous small angular quartz inclusions in the size range of 0.015-0.15 mm which are apparently a natural component of the clay. They are much more common than in the calcium carbonate-tempered ware, and range from about 80 to 160 per field of view.

The variability of temper apparent under the binocular microscope is evident in thin section. The three sections of sherds that exhibited only olivine and iddingsite under reflected light proved to have all the components of olivine temper and no additional additives. The two sherds that each exhibited a green grain with prismatic cleavage also show all the components of olivine temper, and grains with prismatic cleavage are apparently orthopyroxenes in these sherds. A202-62 also had visible quartz, although of a much smaller size class. In thin section it is apparent that this was simply visibility of the largest of the small, non-additive quartz inclusions, for grains up to 0.12 mm were present. The visible quartz in A202-58 which otherwise contained only the components of olivine temper is similarly explained.

A202-60 appeared to have both quartz and rocks as temper in addition to the constituents of olivine temper. In section the dark inclusions appear to be fragments of magnetite or another multiple oxide. A few of them in this section are large enough to appear as grains: one has an apparent diameter of about 1.7 mm. In thin section, all quartz grains are 0.12 mm or less, and probably are natural components of the clay. Reexamination of the sherd in reflected light with the binocular microscope indicates that identification of quartz as a temper was mistaken. Apparently some very pale olivines were taken as quartz, as several of them show a conchoidal fracture. This sherd has a distinctive texture shared with A202-64 because of the smaller size of the temper grains (Figure 3).

A202-64 appeared to have dirty sand as the primary component, accompanied by olivine temper. In thin section, olivine temper proved to be dominant, although of small size. A few temper-sized round rock grains, some identifiably basalt, were present and are readily explained by adherence of some basalt matrix to the zenolith that was crushed for temper.

SAND-TEMPERED SHERDS

Sherd No.	Thin Section No.
A201-1743a	A202-55
A201-1743b	A202-56
A201-1275	A202-57

Under binocular microscope inspection in reflected light, the sand-tempered sherds from Bovine Bluff show less variation in their temper than do sherds we have examined from later sites in the lower Moapa Valley. The Bovine Bluff sherds are all dominated by subangular to well-rounded quartz grains with little or nothing else showing on the fresh break. A201-1743a and A201-1275 were classed as clean quartz sand; A201-1743b also had some rusty inclusions.

Thin sections A202-55 and -57 supported the binocular identification. Temper grains proved to be uniformly quartz, quartzite or quartz-cemented sandstone. Each of these is present in both sections. A202-55 shows no other rocks, but A202-57 has two well-rounded fine-grained rocks of the grain size of the quartz temper. No feldspars, micas, or other mineral grains were identified. The sand temper in each of these sherds does include subrounded grains of caliche in the same size range as the quartz as a minor component. Four caliche grains are present in A202-55; seven in A202-57.

Caliche grains are more numerous in A202-56. Seventeen were counted. Except for the greater number of caliche grains, the temper of A202-56 appears comparable to the other two sand-tempered sections. For some reason, this thin section is of poorer quality than the sections on either side of it on the slide, and many grains are torn away so that grain diameters cannot be measured successfully. A202-56 is omitted from Figure 5, on which grain sizes for A202-55 and -57 are compared and then summed for comparison with sections of calcium carbonate- and sand-tempered pottery.

When Figure 5 is compared with Figures 1 and 4, it can be seen that sand temper is better sorted than the two other tempers. Both calcium carbonate and olivine are crushed rock tempers, and were added with little sorting. The sorting of the sand temper is probably inherent in the sand source itself.

The pastes of all these sherds appear grainy at 28x magnification, and small quartz particles from fine sand size down to into the silt-sized fraction as far as can be resolved are apparent, indicating that a silty clay was used for their production. A202-55 and -57 are from sherds fired to a consistent light gray throughout. A202-56, in contrast, has a slightly darkened core and buff margins. In section, it appears to be suffused with calcium carbonate in comparison with the other two, as though it was more porous. Some differences in clay, or more likely, firing, probably account for the difference, and may explain A202-56's poor response to thin sectioning.

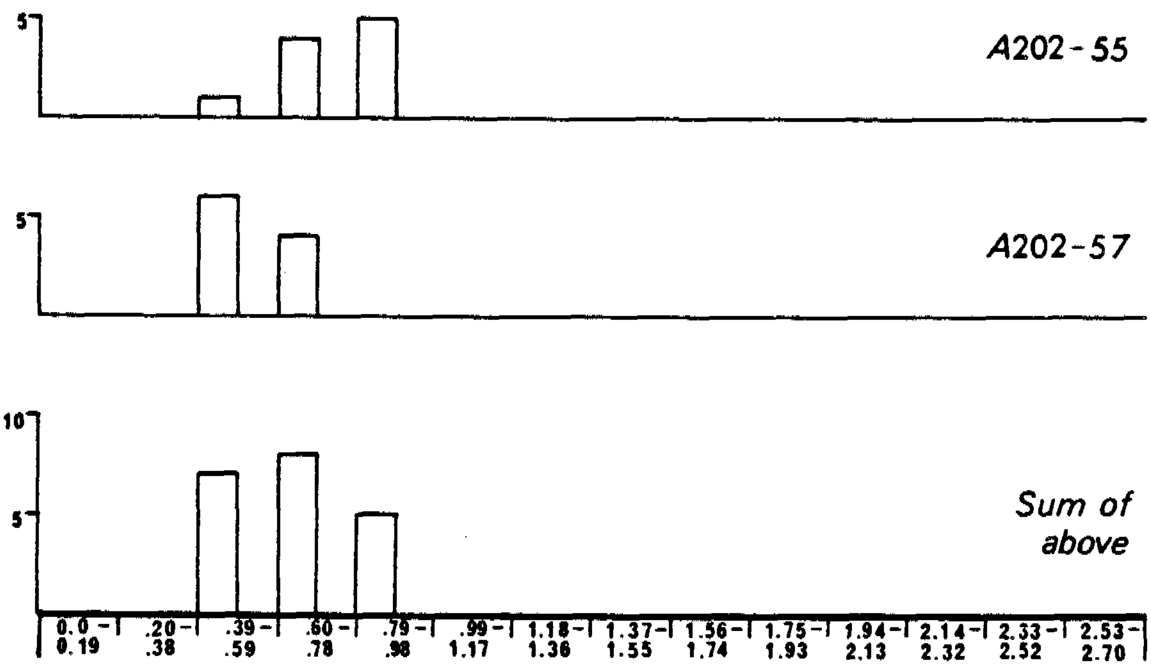

Figure 5. Size distribution of the 10 largest quartz grains in the thin sections of sand-tempered sherds.

Shrinkage cracks are present in A202-55 and -57, although they are much less apparent than in the calcium carbonate-tempered sherds. Rarely are they as long and wide as the cracks in the calcium carbonate-tempered sherds, and they are not nearly so numerous.

SUMMARY

Two very different pastes are present in Bovine Bluff pottery. Within the series of sherds analyzed in thin section, they are associated with distinct tempers. Calcium carbonate temper is found in a relatively silt-free paste with highly developed shrinkage voids. This pottery should be well suited for cooking, for calcite temper's thermal expansion is very similar to low-fired clay, and the shrinkage voids should side-track incipient cracks that begin when the vessel is heated. Both these characteristics confer resistance to thermal shock.

Olivine and quartz have high coefficients of thermal expansion. These tempers are each found in a paste that reflects its origin as a silty clay and has much less shrinkage. This paste may also differ in its clay mineralogy from the silt-free paste. On the other hand, the quantity of silt-sized quartz grains may reduce and diffuse shrinkage of the clays.

Coarse, additive inclusions are apparent in each sherd. Each of the three tempers is used as a discrete additive. Dunite or peridotite zenoliths were crushed to obtain the olivine temper. Limestone was crushed for the calcium carbonate temper. In both these tempers it looks as though the crushed rock was added without screening or other separation, although comparison of Figures 1 and 5 shows a sparsity of particles less than 0.79 mm in the sections of calcium carbonate-tempered pottery in comparison to the olivine-tempered sherds. The latter show an almost normal distribution.

CONCLUSIONS

All characteristics of the crushed limestone and sand-tempered pottery are consistent with local production of these wares. Limestone is readily available in the gravels at Bovine Bluff along with many other rocks. The constituents of the mica-free sand temper are those of Moapa Valley sands. There is no basis for arguing that these wares were necessarily made at the Bovine Bluff site proper, but there is no reason to think that they were not made somewhere in the Moapa Valley. If they are both locally produced, it is apparent that two different clay sources were being used very selectively in their production.

Olivine-tempered sherds consistently contain olivine, iddingsite, orthopyroxene and an opaque multioxide such as magnetite, chromite or chrome spinel. The nature of the olivine temper demands an external source for the temper. Its constituents are comparable enough to a single sample of Tuweep dunite and to sherds from that area to be consistent with an origin in the vicinity of Mt. Trumbull for the temper, but not to rule out other sources. On the other hand, the similarity of the paste to the locally-produced sand-tempered wares is consistent with local production of the pottery with imported temper. This suggestion was offered less seriously some years ago (Thompson 1978:7). Myhrer points out in the main report that olivine-tempered pottery is, on the average, slightly lighter and less yellow in exterior color than sand tempered, however. This may indicate a different clay or firing regime for the two wares. In this problem, as in many others, our understanding of the ceramics of Moapa Valley Anasazi will be enhanced by experiments as well as further studies of their ceramic products.

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APPENDIX 2

RADIOCARBON ANALYSES OF TWO SAMPLES

BETA ANALYTIC INC.
(305) 667-5167
UNIVERSITY BRANCH
P.O. BOX 248113
CORAL GABLES, FLA. 33124

A2-1

REPORT OF RADIOCARBON DATING ANALYSES

FOR: Keith Myhrer
University of Nevada - Las Vegas

DATE RECEIVED: June 13, 1984
DATE REPORTED: July 2, 1984
BILLED TO SUBMITTER'S INVOICE NUMBER

OUR LAB NUMBER	YOUR SAMPLE NUMBER	C-14 AGE YEARS B.P. ± 1σ
Beta-9705	Bovine Bluff A-201-1349	1000 ± 50 B.P.
Beta-9706	Bovine Bluff A-201-1529	1030 ± 80 B.P.

These dates are reported as RCYBP (radiocarbon years before 1950 A.D.). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard; the adjusted ages are normalized to -25 per mil carbon 13.

APPENDIX III

OBSIDIAN SOURCING AND HYDRATION OF EIGHT SPECIMENS

Sonoma State University
Academic Foundation, Inc.

A3-1

ANTHROPOLOGICAL STUDIES CENTER
CULTURAL RESOURCES FACILITY
707 664-2381

September 12, 1985

Dr. Margaret Lyneis
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, Nevada 95112

Dear Dr. Lyneis:

I write to report the hydration band analysis of 14 specimens that you recently forwarded to Richard Hughes for XRF source analysis. The items derived from 2 sites, 26NY809 (4 specimens) and 26CK3130 (10 specimens) specimens). Richard recently completed the XRF analysis and personally passed the specimens on to the Sonoma State University Hydration Lab on Tuesday, September 10.

Hydration analysis of the specimens was completed by the undersigned and staff of the Obsidian Hydration Laboratory at Sonoma State University. The procedures used by Sonoma State University's Hydration Lab for thin-section preparation and hydration band measurement are described below.

Two small parallel cuts were made at an appropriate location along the edge of each specimen with a 4" circular saw blade mounted on a lapidary trimsaw. The cuts resulted in the isolation of small samples that had a thickness of 1 to 2 millimeters. The isolated samples were removed from each specimen and mounted with Lakeside cement to permanently marked microslides.

The reduction of the thickness of each sample was accomplished by manual grinding with #600 silicon carbide abrasive on a water-moistened glass plate. The grinding was completed in two steps to eliminate micro-chips made by the saw blade and to reduce each sample's thickness. The first grind was terminated when a sample's thickness was reduced by approximately 1/2. Each slide was then reheated, which softened the Lakeside cement, and the sample inverted. The newly exposed surface was ground until a final thickness of 30 to 50 microns was attained.

The appropriate thickness of each sample was determined by the "touch" technique, whereby a finger was rubbed across the surface of each slide and on to the sample. The determination of the correct thickness of each sample was made by feeling the difference between the surface of the slide and the surface of the sample. The second technique used for assessing the proper sample thickness is termed the "transparency" test.

1801 East Cotati Avenue   Rohnert Park, California 94928

Each microslide was held against a strong light source and the translucency of each sample observed. Each sample was considered sufficiently reduced when the sample readily allowed the passage of light. When the grinding process was completed, a protective glass coverslip was affixed over each sample with mounting media. The completed microslides are on file at the SSU Obsidian Hydration Lab under Job Number 85-H420.

Microscopic examination of each sample was accomplished with a 10 power objective and measurement of hydration bands was completed with a 45 power objective on an American Optical petrographic microscope equiped with a 12.5X Bausch and Lomb filar micrometer eyepiece that was used to take measurements. Six measurements were obtained at several locations along the edges of each sample. Measurement error is considered to be +/- 0.2 mircons. The average of the six measurements was calculated and included on the enclosed computer generated table.

The abbreviations used under the "Remarks" column on the tables are as follows:

dh = diffuse hydration band (not measureable)
not obs = not obsidian
1st b = smaller of two bands found on a specimen
2nd b = larger of two bands found on a specimen

The specimens are being sent back to you under separate cover.

If you have any questions regarding this hydration information, please do not hesitate to contact me.

Cordially,

Thomas M. Origer, Coordinator
Obsidian Hydration Laboratory

enclosure

cc: Tom Zale, BLM
Las Vegas, Nevada

NV 26NY809 Submitted by: Margaret Lyneis - UNLV September 1985

Lab #	Cat.#	Description	Provenience	Remarks	Readings	Mean	Source
01	A200-710	flake	not provided	1st b	4.4 4.4 4.4 4.4 4.5 4.5	4.4	
01	A200-710	flake	not provided	2nd b	5.7 5.7 5.7 5.8 5.8 5.9	5.8	
02	A207-1108a	biface fragment	not provided	none	4.5 4.6 4.6 4.7 4.7 4.7	4.6	
03	A200-1108b	biface fragment	not provided	none	9.2 9.2 9.2 9.2 9.3 9.3	9.2	
04	A200-731	biface fragment	not provided	none	4.5 4.5 4.5 4.5 4.6 4.7	4.6	

Lab Accession No.: H420 Technician: Thomas Origer

NV 26CK3130 Submitted by: Margaret Lyneis - UNLV September 1985

Lab #	Cat.#	Description	Provenience	Remarks	Readings	Mean	Source
05	A201-1230	biface fragment ?	not provided	not obs			
06	A201-1345	nodule fragment	not provided	none	5.5 5.5 5.6 5.7 5.7 5.8	5.6	
07	A201-1424	nodule fragment	not provided	none	4.8 4.8 4.8 4.9 4.9 5.1	4.9	
08	A201-1470	nodule fragment	not provided	not obs			
09	A201-1548	flake	not provided	none	7.5 7.6 7.7 7.7 7.7 7.7	7.7	
10	A201-1563	flake	not provided	none	5.8 5.9 5.9 5.9 6.0 6.2	6.0	
11	A201-1586	nodule fragment	not provided	dh			
12	A201-1747	flake	not provided	none	6.2 6.3 6.3 6.4 6.5 6.5	6.4	
13	A201-1875	flake	not provided	dh			
14	A201-1892	flake	not provided	none	6.5 6.6 6.6 6.6 6.7 6.8	6.6	

Lab Accession No.: H420 Technician: Thomas Origer

September 18, 1985

Mr. Keith Myhrer
Department of Anthropology and Ethnic Studies
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154

Dear Mr. Myhrer:

Enclosed please find xerox copies of data sheets presenting x-ray fluorescence data generated from the analysis of fourteen artifacts from 26 CK 3130 (n=10), located about two miles south of Moapa, Nevada, and 26 NY 809 (n=4) located west of the Manse Ranch near Pahrump, Nevada. This analysis was conducted at the request of Dr. Margaret M. Lyneis, pursuant to U.S.D.I., Bureau of Land Management Purchase Order No. NV050-PH5-95 (26 CK 3130) and University of Nevada, Las Vegas, Purchase Order No. 16989 (26 NY 809), under Sonoma State University Academic Foundation, Inc., Account 6081, Job X85-21.

Laboratory investigations were conducted at the Department of Geology and Geophysics, University of California, Berkeley, on a Spectrace™ 440 (United Scientific Corporation) energy dispersive x-ray fluorescence machine equipped with a 572 power supply (50 kV, 1 mA), 534-1 pulsed tube control, 514 pulse processor (amplifier), 588 bias/protection module, Tracor Norther 1221 100 mHz analog to digital converter (ADC), Tracor Northern 2000 computer based analyzer, an Rh x-ray tube and a Si(Li) solid state detector with 142 eV resolution (FWHM) at 5.9 keV in a 30 mm^2 area. The x-ray tube was operated at 30.0 kV, .40 mA pulsed, with a .04 mm Rh primary beam filter in an air path at 200 seconds livetime. All trace element measurements on the data sheets are expressed in quantitative units (i.e. parts per million [ppm] by weight), and these were compared directly to values for obsidian sources that appear in Jack (1971, 1976), Hughes (1983, 1985, 1986), Nelson (1984) and Nelson and Holmes (1979).

Source assignments were made by comparing diagnostic trace element concentration (ppm) values (Rb, Sr, Y and Zr) for artifacts with values for known obsidian sources. Of ten artifacts analyzed from 26 CK 3130, one specimen (Cat. no. 1424) matches the trace element signature of Kane Springs obsidian, two specimens (Cat. nos. 1230 and 1470) were fashioned from non-obsidian raw material, while the remaining seven specimens (Cat. nos. 1345, 1875, 1548, 1747, 1892, 1586 and 1563) do not possess trace element concentration values that correspond with any of the standards in the obsidian source data base. It is clear, however, that all seven of these specimens represent to the same geochemical type; i.e., they very likely represent the same obsidian source. Source attributions also could not be made for three (Cat. nos. 1108A, 731 and 710) of the four artifacts analyzed from 26 NY 809. Again, trace element values indicate that these three specimens probably derive from the same "unknown" obsidian source, but not the same one identified in the CK 3130 assemblage. The final NY 809 specimen (Cat. no. 1108B) has Rb, Sr and Zr ppm values that overlap with obsidian sources in central eastern California (Mono Craters, Mono Glass Mountain and Fish Springs) and one in western Nevada (Crow Spring). Consequently, it be necessary to conduct an additional analysis on this specimen (to determine its Fe/Mn ratio) before an obsidian source attribution can be advanced. If you'd like, I would be willing to conduct this analysis as soon as possible.

The vast majority of obsidian in this sample of CK 3130 and NY 809 artifacts was not obtained from known sources. Despite the fact that artifact-to-source ascriptions cannot be made at this time, one obvious conclusion from this study is that at least two undocumented obsidian sources exist in these portions of southern Nevada and/or adjacent areas, and that they were employed (at least locally) in artifact manufacture. Hopefully, these localities will be discovered in the course of future reconnaissances for obsidian and welded ash-flow tuff sources in southern Nevada.

I hope this information will help in your analysis of these site materials. Please contact me if I can be of further assistance.

Sincerely,

Richard E. Hughes

Richard E. Hughes, Ph.D.
Senior Research Archaeologist
Anthropological Studies Center
Sonoma State University
Rohnert Park, CA 94928

cc: Tom Zale, BLM, Las Vegas

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26 CK 3130 XRF
8-14-85
R.E. Hughes

Cat. No.	CHSQ	Pb*	Th*	Rb*	Sr*	Y*	Zr*	Nb*
1230	1.4	16.7	0.0	0.0	5.1	0.9	45.9	0.0
		+- 1.9	+- 0.0	+- 0.0	+- 2.1	+- 2.9	+- 2.5	+- 0.0
1345	4.4	25.2	27.7	162.4	12.1	46.9	157.5	25.6
		+- 2.5	+- 4.9	+- 4.1	+- 2.5	+- 4.2	+- 3.8	+- 2.6
1875	3.7	29.2	30.5	168.1	11.6	48.5	156.1	28.5
		+- 2.9	+- 5.6	+- 4.5	+- 2.8	+- 4.7	+- 4.2	+- 2.9
1548	3.8	24.7	22.1	178.6	13.7	47.1	157.6	22.8
		+- 2.8	+- 5.6	+- 4.5	+- 2.8	+- 4.7	+- 4.2	+- 2.7
1470	1.2	9.0	13.1	0.0	0.9	0.0	33.5	0.0
		+- 1.3	+- 2.7	+- 0.0	+- 1.5	+- 0.0	+- 1.8	+- 0.0
1747	6.4	27.8	32.7	179.1	13.3	47.2	166.8	27.2
		+- 1.8	+- 3.7	+- 3.1	+- 1.8	+- 3.1	+- 2.9	+- 2.0
1892	3.6	30.2	37.2	169.6	10.4	51.2	162.8	27.0
		+- 3.0	+- 6.0	+- 4.9	+- 3.0	+- 5.0	+- 4.5	+- 3.1
1586	6.2	24.8	30.8	173.1	12.2	46.8	162.4	28.6
		+- 1.8	+- 3.7	+- 3.1	+- 1.8	+- 3.1	+- 2.0	+- 2.0
1563	5.0	29.8	26.8	178.6	11.4	54.0	166.6	27.0
		+- 2.2	+- 4.4	+- 3.8	+- 2.2	+- 3.8	+- 3.5	+- 2.4
1424	5.1	30.7	33.5	200.3	34.3	33.5	157.9	25.4
		+- 2.1	+- 4.2	+- 3.6	+- 2.4	+- 3.5	+- 3.2	+- 2.2

*All values in parts per million (ppm); ± = counting error uncertainty

26 NY 809 XRF
8-14-85
R.E. Hughes

Cat. No.	CHSQ	Pb*	Th*	Rb*	Sr*	Y*	Zr*	Nb*
1108A	4.0	30.9	33.1	183.3	73.2	26.3	187.1	21.0
		+- 2.5	+- 4.9	+- 4.1	+- 3.2	+- 3.9	+- 4.0	+- 2.5
1108B	4.7	33.7	32.8	215.2	0.0	43.4	112.1	29.4
		+- 2.4	+- 4.6	+- 4.1	+- 0.0	+- 3.9	+- 3.1	+- 2.4
731	4.4	26.4	34.2	182.6	69.0	23.3	196.0	20.9
		+- 2.3	+- 4.6	+- 3.8	+- 2.9	+- 3.6	+- 3.7	+- 2.3
710	3.9	32.7	33.6	187.9	75.5	23.8	193.9	19.8
		+- 2.6	+- 5.1	+- 4.3	+- 3.3	+- 4.0	+- 4.1	+- 2.6

*All values in parts per million (ppm); ± = counting error uncertainty

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